# Advanced Scientific Computing Research

## Program Mission

The primary mission of the Advanced Scientific Computing Research (ASCR) program, which is carried out by the Mathematical, Information, and Computational Sciences subprogram, is to discover, develop, and deploy the computational and networking tools that enable researchers in the scientific disciplines to analyze, model, simulate, and predict complex phenomena important to the Department of Energy. To accomplish this mission the program fosters and supports fundamental research in advanced scientific computing – applied mathematics, computer science, and networking – and operates supercomputer, networking, and related facilities. The applied mathematics research efforts provide the fundamental mathematical methods to model complex physical and biological systems. The computer science research efforts enable scientists to efficiently run these models on the highest performance computers available and to store, manage, analyze, and visualize the massive amounts of data that result. The networking research provides the techniques to link the data producers; e.g., supercomputers and large experimental facilities with scientists who need access to the data.

In fulfilling this primary mission the ASCR program supports the Office of Science Strategic Plan's goal of providing extraordinary tools for extraordinary science as well as building the foundation for the research in support of the other goals of the strategic plan. In the course of accomplishing this mission, the research programs of ASCR have played a critical role in the evolution of high performance computing and networks.

In addition to this primary mission, the ASCR program is also responsible for the Laboratory Technology Research subprogram in the Office of Science, whose mission is to foster and support high-risk research in the natural sciences and engineering in partnership with the private sector leading to innovative applications relevant to the Nation's energy sector.

The high quality of the research in the entire ASCR program, supporting both of its missions, is continuously evaluated through the use of merit-based peer review and scientific advisory committees.

## Program Goals

- Maintain world leadership in areas of advanced scientific computing research relevant to the missions of the Department of Energy.
- Integrate the results of advanced scientific computing research into the natural sciences and engineering.
- Provide world-class supercomputer and networking facilities for scientists working on problems that are important to the missions of the Department.
- Integrate and disseminate the results of high-risk research in natural sciences and engineering to the private sector through the Laboratory Technology Research subprogram.

## Program Objectives

- *Advance the frontiers of knowledge in advanced scientific computing research.* – Foster research to create a new fundamental knowledge in areas of advanced computing research important to the Department, e.g., high performance computing, high speed networks to support scientific collaborations, and software to enable scientists to make effective use of the highest performance computers available.

- *Apply advanced computing knowledge to complex problems of importance to DOE.* — Promote the transfer of the results of advanced scientific computing research to DOE missions in areas such as the improved use of fossil fuels including understanding the combustion process; the atmospheric and environmental impacts of energy production and use including global climate modeling and subsurface transport; and future energy sources including fusion energy as well as the fundamental understanding of matter and energy.
- *Plan, construct, and operate premier supercomputer and networking facilities.* — Serve researchers at national laboratories, universities, and industry, thus enabling both new understanding through analysis, modeling, and simulation of complex problems and effective integration of geographically distributed teams through national collaboratories.
- *Transfer results of fundamental research to the private sector.* — Provide tangible results of research and development activities through cost-shared partnerships with industry.

## Performance Measures

The Advanced Scientific Computing Research program measures performance in various ways, depending on the objective. However, performance measures fall into four broad categories:

- peer review, which is the key performance measurement process of all research activities;
- indicators or metrics (i.e., things that can be counted);
- customer evaluation and stakeholder input; and
- qualitative assessments, which might include historical retrospectives and annual program highlights.

Facility performance measures include achievement of performance specifications, operating time, throughput, user satisfaction, and effective utilization of resources as determined by reports from external review panels, user steering committees, and internal Office of Science (SC) program manager committees. In addition, ASCR supercomputer and network facilities have periodic external performance reviews. The Energy Sciences Network (ESnet) operations and management were reviewed in this manner in FY 1998.

Performance Measures for FY 2001 include:

- conduct regular peer review and merit evaluation based on the principles set down in 10 CFR Part 605 for grants and cooperative agreements, with all research projects reviewed at least once and no project extending more than four years without review;
- support the Computational Science Graduate Fellowship Program with the successful appointment of 10 new students to support the next generation of leaders in computational science for DOE and the Nation;
- the operating time lost at scientific facilities due to unscheduled NERSC/ESnet downtime will be less than 10 percent of the total scheduled possible operating time, on average;
- facilities, including the National Energy Research Scientific Computing Center (NERSC) and ESnet, will be operated within budget and successfully meet user needs and satisfy overall SC program requirements where, specifically, NERSC will deliver 3.6 Teraflop capability by the end of FY 2001 to support DOE's science mission;
- work performed by investigators supported by ASCR will continue to be recognized as outstanding through the receipt of major prizes and awards;
- the Laboratory Technology Research subprogram will complete its review of projects initiated during the previous year to ensure that research objectives and program goals are being met;

- research in predictability of computer simulations will provide a common intellectual foundation and a set of tools for evaluating predictability issues. These tools will be used by initiatives to use computational simulation across the Department, including climate research, combustion modeling, and stockpile stewardship.
- the Advanced Computing Research Facilities program will provide new insights into the usefulness of novel high performance computing architectures for science.
- complete reviews on Laboratory Technology Research portfolio (1) to ensure that satisfactory progress has been made toward stated objectives and (2) to assess the scientific quality of the research performed to date.

## Significant Accomplishments and Program Shifts

The FY 2001 budget includes substantial enhancements to our research portfolio to build the next generation of high performance computing and communications tools to support the missions of the Office of Science and the Department of Energy in the next century. Increased funding in the areas of advanced scientific computing will be described in more detail in the Mathematical, Information, and Computational Sciences subprogram section.

A new Federally-chartered advisory committee has been established for the Advanced Scientific Computing Research program and has been charged with providing advice on: promising future directions for advanced scientific computing research; strategies to couple advanced scientific computing research in other disciplines; and the relationship of the DOE program to other Federal investments in information technology research. This advisory committee will play a key role in evaluating future planning efforts for research and facilities.

The ASCR program builds on decades of leadership in high performance computing. Some of the pioneering accomplishments of this program are:

**Mathematical, Information, and Computational Sciences (MICS)**

- **Established First National Supercomputer Center.** In 1974, DOE established the National Magnetic Fusion Energy Computing Center [the predecessor to the National Energy Research Scientific Computing Center (NERSC)], and pioneered the concept of remote, interactive access to supercomputers. Before this time, scientists using supercomputers had to travel to the location of the computer to make use of it. In addition, users were only able to use these computers by submitting jobs and waiting for hours or days to see the output. The Mathematical, Information, and Computational Sciences (MICS) subprogram developed the first interactive operating system for supercomputers, Cray Time Sharing System (CTSS), as well as a nationwide network to allow remote users to have effective access to the computers. This operating system revolutionized access to supercomputers by enabling users to monitor their jobs as they executed. When the National Science Foundation (NSF) initiated its Supercomputer Centers program in the 1970's, the CTSS operating system was adopted by the San Diego Supercomputing Center and the National Center for Supercomputing Applications to enable users to access NSF's first CRAY machines.
- **Laid Mathematical Foundations for High Performance Computing: Numerical Linear Algebra Libraries.** Today's high performance scientific computations rely on high performance, efficient libraries of numerical linear algebra software. These libraries, which are the core of

numerical efforts in the solution of differential and integral equations LINPACK, EISPAC, LAPACK, SCALAPACK are the direct result of decades of DOE funding of basic research in this area. These libraries are used by thousands of researchers worldwide and are a critical part of the world's scientific computing infrastructure.

- **Developed High Speed Interconnects for Supercomputers: High Performance Parallel Interface (HiPPI).** In order to develop a standard interface between supercomputers and other devices, such as disk arrays and archival tape systems, and visualization computers, DOE laboratories developed the high performance network interface (HiPPI) and led a consortium of vendors to make it the industry standard for the highest bandwidth interconnects between computers and peripheral devices. This advance required the solution of many problems in high speed signaling, data parallelism and high speed protocol design had to be understood to enable this advance.
- **Led the Transition to Massively Parallel Supercomputing: Parallel Virtual Machine (PVM) and Message Passing Interface (MPI).** DOE researchers developed PVM and MPI to enable scientists to make effective use of networks of workstations and massively parallel computers. Both of these software packages have become standards in the industry and are implemented by virtually all of the high performance computer manufacturers in the world. Both of these developments were enabled by over a decade of basic research in message passing and distributed computing supported by DOE along with many experiments to apply these techniques to real scientific problems.
- **Contributed to the Development of the Internet: Slow Start Algorithm for the Transmission Control Protocol (TCP).** Transmission Control Protocol (TCP) part of TCP/IP (Internet Protocol) is responsible for ensuring that packets arrive at their destination. In 1987, as DOE and the other Federal agencies were interconnecting their networks to form the core of the Internet, critical parts of the infrastructure began to fail. There was concern that this represented a fundamental flaw in the TCP/IP architecture; however, a researcher at LBNL applied ideas from fluid flow research to understand the problem and develop a solution. This new TCP algorithm was incorporated in virtually every commercial version of Internet software within six months and enabled the Internet to scale from a small research network to today's worldwide infrastructure.

Building on this long history of accomplishments, principal investigators of the Advanced Scientific Computing Research program this year received recognition through numerous prizes, awards, and honors. A sample of the significant accomplishments and awards produced by the program this year is given below.

## Mathematical, Information, & Computational Sciences

- **Parallel Computational Oil Reservoir Simulator.** To meet the Nation's energy needs, the United States oil and gas industry must continue to advance the technology used to extract oil and gas from both new and old fields. Until recently, most drilling and recovery activities were based on past practices that often lacked a sound scientific basis. Computer scientists at Argonne National Laboratory, in collaboration with petroleum engineers at the University of Texas at Austin, have recently developed a software package capable of simulating the flow of oil and gas in reservoirs. These codes, which are based on software tools designed at Argonne, are able to run on a variety of computer platforms, including massively parallel systems with hundreds and even thousands of processors. The software codes will enable the oil and gas industry to lower exploration and drilling costs and enhance the yield of oil from new and old fields alike.
- **Predictability Research Program.** Understanding the behavior of solids, liquids and gases under extreme conditions of temperature and pressure is often the key to understanding complex physical

systems that are critical to a number of the missions of the Department of Energy. The physical conditions under which the devices operate are often so extreme that it is not possible to perform laboratory experiments to validate the design of the devices. Faced with such limitations scientists and engineers are turning more and more to the use of high-speed computers to simulate the behavior of matter under conditions that are not amenable to experimental verification. Under funding from the new MICS Predictability research program a multidisciplinary team of researchers from the Los Alamos and Sandia National Laboratories has performed highly accurate simulations of shockwave-induced fluid instabilities (that are known as Richtmyer-Meshkov instabilities). The simulations match results from "gas-curtain" experiments also conducted by the team over several physically important parameter ranges that can be measured in the laboratory. Researchers are now computationally exploring the behavior of real systems in crucial parameter ranges that are outside of experimental verifiability. This work has broad applicability to our ability to simulate advanced fluid and combustion systems.

- **Theory of Nonequilibrium Solids.** The melting of solids into liquids is a very common, but poorly understood phenomenon that appears in a host of scientific and engineering problems of importance to the Department of Energy. With the appearance of high speed computers in recent years, scientists have been able to couple simulation to theoretical and experimental investigations of melting phenomena, resulting in advances in our understanding of the underlying physics and material properties of solids undergoing melting. An applied mathematician and a materials scientist at the Oak Ridge National Laboratory discovered three distinct "hidden structures" in the melting of two-dimensional materials. This totally unexpected finding has awakened interest among theorists, and it has set off an intense search for additional structures in both two- and three-dimensional problems. This fundamental discovery was enabled by coupling the expertise of the applied mathematician in numerical methods, the expertise of the materials scientist in developing the equations to describe the system, and access to significant high performance computing resources.
- **High Performance Algorithms for Scientific Simulation.** Many problems in science and engineering involve the complex interplay of forces and effects on different time and length scales. Two significant examples of such nonlinear multi-time, multi-scale phenomena are the interaction of the atmosphere and the oceans in the creation of the global climate and the burning of fossil fuels in engines and other devices. The size and complexity of such problems require the development of fast and efficient algorithms and software that can take advantage of the resolution power of today's massively parallel computing platforms. Applied mathematicians at the Lawrence Berkeley National Laboratory, working in collaboration with applied mathematicians at the Lawrence Livermore National Laboratory and New York University, have developed adaptive mesh refinement algorithms capable of automatically redistributing grid points in computational regions where significant physics is occurring over small time scales. At finer and finer length scales the continuous flow solver is replaced by a particle method such as Monte Carlo, thus allowing the researchers to accurately resolve phenomena over a broad range of length and time scales. Applications of this work to the Accelerated Strategic Computing Initiative (ASCI) and Office of Science problems are many, although the primary focus of the research is the accurate simulation of diesel combustion in realistic, three-dimensional geometries. The laboratory and academic researchers are working on this project closely with engineers from Caterpillar and Cummins.
- **Real-time Reconstruction of Microtomographic Data at the Advanced Photon Source.** The use of X-rays as a non-destructive tool for investigating the internal structure of materials at the micron length scale has grown rapidly over the last decade due to the advent of synchrotron radiation sources such as the Advanced Photon Source (APS). Unfortunately, while advanced detector technology now allows gigabytes of data to be collected in tens of minutes, the computing technologies required to translate this data into images and hence insight have not kept pace. Recent

work at Argonne National Laboratory and the University of Southern California's Information Sciences Institute (ISI) has produced new techniques that overcome this problem. By using a combination of high-performance networking and computing resources, parallel reconstruction algorithms, and advanced resource management, communication, and collaboration software, the Argonne/ISI team was able to demonstrate quasi-real-time 3-D imaging of samples of an APS tomographic beamline. The results as demonstrated in a live run in early May 1999, are stunning: ten minutes after data collection starts, an initial 3-D image appears on the screens of project scientists both at Argonne and at other institutions. Over the next 20 minutes, this image is progressively refined as more data is obtained. For the first time, scientists can change experimental parameters in the middle of an experiment. The implications for better use of scarce facilities and for higher-quality science are clear. This new capability was made possible by support from the ASCR Grand Challenge program and by the parallel computers of Argonne's Center for Computational Science and Technology; it also makes extensive use of distributed computing and collaboration technologies developed under the DOE2000 computing program.

- **Pacific Northwest National Laboratory Researchers Win Best Paper Award at Supercomputing '98.** A paper authored by scientists from DOE's Pacific Northwest National Laboratory entitled, "An Out-of-Core Implementation of the COLUMBUS Massively-Parallel Multireference Configuration Interaction Program" received the Best Application Paper and the Best Overall Paper awards at the Supercomputing '98 conference on November 12, 1998, in Orlando, FL. The paper describes a novel parallelization approach developed to enable COLUMBUS, a legacy chemistry application, to be run efficiently on massively parallel computer platforms rather than the vector supercomputers for which it was originally written. This work was accomplished using Global Arrays, one of the DOE2000 Advanced Computational Testing and Simulation (ACTS) tools supported by MICS. Global Arrays provide a portable shared-memory programming environment optimized for the nonuniform memory hierarchy of modern computer architectures. The chemistry part of this project was supported by the MICS subprogram under the Phase II Grand Challenge program.
- **Argonne Researchers Win "Best of Show" Award at Supercomputing '98.** A team of Argonne scientists and their collaborators received the High-Performance Computing Challenge "best of show" award at the Supercomputing '98 conference for their work on innovative wide-area applications using the GUSTO high-performance distributed grid testbed. GUSTO (Globus Ubiquitous Supercomputing Testbed Organization) is a prototype for future computational grids that will link supercomputers, scientific instruments, virtual reality environments, and data archives transparently. It uses software developed by the Globus project, a multi-institutional collaborative project centered at Argonne and the University of Southern California's Information Science Institute funded by ASCR.
- **Supercomputing (SC'99) Awards.** Special awards were given to scientists from Argonne National Laboratory and University of Chicago for their achievements in simulating incompressible flows and another special award was given to a team of scientists from NASA and DOE laboratories for their achievements in fluid dynamics simulations.
- **TelePresence Microscopy Video Wins the Prestigious Crystal Award of Excellence.** The TelePresence Microscopy project that is part of the DOE2000 program at Argonne National Laboratory's (ANL) Material Sciences Division and is jointly funded by the Department's Mathematical, Information, and Computational Sciences subprogram and the Basic Energy Sciences program, both part of the Office of Science, has won the Prestigious Communicator's "Crystal Award of Excellence." The video was produced in collaboration with ANL's Materials Science Division, the National Institute of Standards and Technology, and Texas Instruments. The video was also funded under the auspices of the "IDEA" program at Texas Instruments and the Office of

MicroElectronics programs at the National Institute of Standards and Technology. The Communicator's Award is a national competition founded by communications professionals to recognize individuals and companies in the communications field whose talent and creativity achieves a high standard of excellence and serves as a standard for the industry.

- **The Maxwell Prize.** A new international prize in applied mathematics, the Maxwell Prize, has been awarded for MICS supported research at the Applied Mathematics Research program at Lawrence Berkeley National Laboratory. The research involved analysis of problems dominated by complexity, such as turbulence, failure and cracks in solids, flow in porous and inhomogeneous media, and combustion. The work on crack formation provided some of the basic tools used today in failure analysis, especially failure due to fatigue.

## Laboratory Technology Research (LTR)

The LTR subprogram received five R&D-100 Awards in 1999 for the following research:

- Argonne National Laboratory, in collaboration with the Association of American Railroads and the Electro-Motive Division of General Motors, has developed a technology that should allow diesel engines to operate more cleanly and efficiently. The technology simultaneously minimizes emission of fine-particle pollution and oxides of nitrogen during combustion. It has been demonstrated in a locomotive diesel, but should apply to all types of diesel engines, including those in trucks, buses, heavy equipment, and cars. Practical and less expensive than alternative technologies, it could end a long-standing struggle with diesel pollution.
- Brookhaven National Laboratory, in collaboration with W.R. Grace, has developed the first product capable of destroying asbestos in installed fireproofing on building columns and beams without reducing the fire-resistive performance of the fireproofing material. The new technique, which is now commercially available, uses a foamy solution sprayed directly onto asbestos-containing fireproofing. The foam chemically digests nearly all of the asbestos fibers, dissolving them into harmless minerals. After being treated, the fireproofing is no longer a regulated material. The new process produces essentially no waste and is expected to save building owners the expense of disposing of regulated waste materials.
- Oak Ridge National Laboratory (ORNL), in collaboration with Minnesota Mining and Manufacturing (3M), has developed a new route to the fabrication of high temperature superconducting (HTS) wires for high power applications. These HTS materials have tremendous potential for greatly improved energy efficiency in a number of power applications related to the utilization of electric energy.
- Pacific Northwest National Laboratory (PNNL), in collaboration with DuPont, has developed a suite of programs for massively parallel computing platforms called the "Molecular Sciences Software Suite (MS3)." The new code has been successful in a number of applications to complex problems in the chemical and biochemical sciences. DuPont has used the technology to study the photochemistry of polymeric and agrochemical systems and for rational design of new dyes.
- PNNL, in collaboration with Finnegan MAT, has developed a novel source for enhanced ion detection. The "electrodynamic ion funnel" focuses ions in gases, greatly improving the sensitivity of analytical devices, such as mass spectrometers, that depend on ion formation and transfer in gases. The concept provides a major breakthrough in the field of electrospray mass spectrometry, which will impact fundamental studies in the biological, chemical, and environmental sciences.

In addition to the R&D-100 Awards, six scientists supported by the LTR subprogram were recipients of the following distinguished awards in 1999:

- A Genius Grant from the MacArthur Foundation for development of a method for tricking cells into expressing non-natural sugars on their surface.

- The 39th Annual G.H.A. Clowes Memorial Award for development of therapeutic approaches to breast cancer.
- The American Physical Society's James C. McGroody Prize for innovations in the growth of diamond and germanium crystals.
- The Humboldt Research Award for work on "lab-on-a-chip" micro devices, capable of carrying out chemical measurements normally performed in a conventional laboratory.
- A Federal Laboratory Consortium Award for work on microbiologically influenced corrosion in industrial environments.
- A Presidential Early Career Award for Scientists and Engineers for development of materials and methods that substantially improve the effectiveness of non-thermal plasma technology in treating nitrogen oxide emissions from vehicles.

In FY 1999, the Laboratory Technology Research subprogram initiated a portfolio of Rapid Access Projects that address research problems of small businesses by utilizing the unique facilities of the Office of Science laboratories. These projects were selected on the basis of scientific, technical and potential commercial merit, using competitive external peer review.

## Advanced Energy Projects (AEP)

The Advanced Energy Projects subprogram was terminated in FY 2000.

## Scientific Facilities Utilization

The ASCR program request includes $32,278,000 in FY 2001 to support the National Energy Research Scientific Computing (NERSC) Center. This investment will provide computer time for about 2,000 scientists in universities, federal agencies, and U.S. companies. It will also leverage both federally and privately sponsored research, consistent with the Administration's strategy for enhancing the U.S. National science investment. The proposed funding will enable NERSC to maintain its role as the Nation's largest, premier unclassified computing center, which is a critical element in the success of many SC research programs. Research communities that benefit from NERSC include structural biology; superconductor technology; medical research and technology development; materials, chemical, and plasma sciences; high energy and nuclear physics; and environmental and atmospheric research.

## Taking The Next Steps in Scientific Computing, Networking, and Collaboration

The accomplishments of the MICS subprogram in scientific computing and enabling distributed scientific teams to work together were described in the ASCR program mission section above. However, additional investments will be required to enable DOE to take the next steps in scientific simulation and to address the challenges that it faces in simulating the complex multidisciplinary phenomena that lie at the heart of its missions. These investments focus on software issues that must be addressed to support today's high performance computers and future computers with significantly higher performance and complexity. They include funding for existing multi-teraflop computers; geographically-dispersed teams of disciplinary scientists, computer scientists, and applied mathematicians; and the supporting infrastructure. Therefore, in FY 2001 the MICS subprogram will enhance its efforts to produce the scientific computing, networking and collaboration tools that DOE researchers will require to address the scientific challenges of the next decade. These enhancements build on the historic strength of the Department of Energy in computational science, computer science, applied mathematics, and high-performance computing and in the design, development, and management of large scientific and engineering projects and scientific user facilities. They also take full advantage of the dramatic increases in computing capabilities being fostered by the *Accelerated Strategic Computing Initiative* (*ASCI*) in the Office of Defense Programs.

**Scientific Computing**

During the past quarter century computational simulation has dramatically advanced our understanding of the fundamental processes of nature and has been used to gain insights into the behavior of such complex natural and engineered systems as the earth's climate and automobile design. The new generation of terascale computing tools, and the 1,000 times more powerful petascale computing capabilities that are now on the horizon, will enable scientists to dramatically improve their understanding of the fundamental processes in many areas. In addition, these new tools will enable scientists to predict the behavior of many complex natural and engineered systems from a knowledge of the underlying physical, chemical, and biological processes involved. This new capability, to predict the behavior of complex systems based on the properties of their components, will change the way DOE and other government agencies solve their most demanding, mission-critical problems. A workshop held at the National Academy of Sciences in July 1998 identified opportunities for new scientific discovery through advanced computing in all of the programs of the Office of Science. The proposed investments to provide programs in computational biology, materials science, chemistry, climate modeling, fusion energy, and high energy and nuclear physics to realize some of these opportunities are discussed in the budgets of those programs.

However, success in those programs depends on investments in applied mathematics and computer science to provide the algorithms, mathematical libraries, and underlying computer science tools to enable the scientific disciplines to make effective use of terascale computers. Despite considerable progress during the past ten years in making massively parallel computer systems usable for applications, much remains to be done. The next generation computer systems to enable leading-edge applications will have between 5,000 and 10,000 individual computer processors rather than the 500-1,000 processors in today's typical high performance systems. In addition, the internal structure of the computers will become more complex as computer designers are forced to introduce more layers of memory hierarchy to maintain performance and develop new hardware features to support rapid communication and synchronization. The end result five years from now will be hardware systems that, while having their roots in today's systems, will be substantially different and substantially more complex and therefore more challenging to exploit for high performance. These challenges will require substantial improvements in parallel computing tools, parallel I/O (input/output) systems, data management, algorithms, and program libraries that must work together as an integrated software system. In addition to the fundamental research challenges that are implied by this evolution in computer hardware, DOE must integrate the output from successful MICS-supported research projects into integrated sets of software tools that scientists in disciplines such as global climate, materials sciences, or computational biology can build on to address scientific challenges.

The MICS subprogram will address these challenges by establishing a small number of competitively selected partnerships (based on a solictation notice to labs and universities) focused on discovering, developing, and deploying to scientists key enabling technologies. These partnerships, which will be called enabling technology centers, must support the full range of activities from basic research through deployment and training because the commercial market for software to support terascale scientific computers is too small to be interesting to commercial software providers. These centers will build on the successful experience of the MICS subprogram in managing the DOE2000 initiative, as well as on the lessons learned in important programs supported by DARPA such as Project Athena at MIT, the Berkeley Unix Project, and the initial development of the Internet software and the Internet Activities Board (IAB). These enabling technology centers will have close ties to key scientific applications projects to ensure their success.

**Networking and Collaboration**

Advances in network capabilities and network-based technologies now make it possible for large geographically-distributed teams to effectively collaborate. This is especially important for the teams using the major experimental facilities, computational resources, and data resources supported by DOE. With leadership from DOE, these geographically distributed laboratories or collaboratories have begun to play an important role in the Nation's scientific enterprise. The importance of collaboratories is expected to increase in the future. However, significant research questions must be addressed if collaboratories are to achieve their potential: to enable remote access to petabyte/year High Energy and Nuclear Physics (HENP) facilities such as the Relativistic Heavy Ion Collider (RHIC) to be the same as "being there;" to provide remote visualization of terabyte to petabyte data sets from computational simulation; and to enable effective remote access to tomorrow's advanced scientific computers.

- First, new capabilities are required in the nationwide scientific networks to support collaboratories. For example, using the current Internet, it would take about 2,500 hours to transmit one day's data from RHIC to one remote site for analysis. Typical RHIC experimental collaborations involve thousands of scientists and hundreds of institutions spread across the country and the world who need access to millions of gigabytes (petabytes) of data (a billion times as much data as a large web page). This situation is very different than data management in the commercial sector where millions of users are moving to web pages. Significant research is needed to enable today's commercial networks to be used for scientific data retrieval and analysis. This includes research on advanced protocols, special operating system services to support very high speed transfers, and advanced network control.
- Second, research is needed to understand how to integrate the large number of network devices, network-attached devices, and services that collaboratories require. Examples of the components and services that need to be integrated include: network resources, data archives on tape, high performance disk caches, visualization and data analysis servers, authentication and security services, and the computer on a scientist's desk. All of these physical and software services must be tied together by common software framework building blocks or "middleware" to enable the collaboratories of the future to succeed.

The MICS subprogram will address these challenges through an integrated program of fundamental research in networking and collaboratory tools, partnerships with key scientific disciplines, and advanced network testbeds.

**Enhancements to Computing and Networking Facilities**

To realize the scientific opportunities, enhancements to the Office of Science's computing and networking facilities are also required. The current computers at NERSC provide less than half of the computer resources that were requested last year. This pressure on the facility will only increase in future years as more applications become ready to move from testing the software to using the software to generate new science. In addition, as the speed of computers increases, the amount of data they produce also increases. Therefore, focused enhancements to the Office of Science's network infrastructure is required to enable scientists to access and understand the data generated by their software. These network enhancements are also required to allow researchers to have effective remote access to the experimental facilities that the Office of Science provides for the Nation.

### Interagency Environment

The research and development activities supported by the MICS subprogram are coordinated with other Federal efforts through the Interagency Principals Group, chaired by the President's Science Advisor, and the Information Technology Working Group (ITWG). The ITWG represents the evolution of an interagency coordination process that began under the 1991 High Performance Computing Act as the High Performance Computing, Communications, and Information Technology (HPCCIT) Committee. DOE has been a key participant in these coordination bodies from the outset and will continue to coordinate its R&D efforts closely through this process.

In FY 1999, the President's Information Technology Advisory Committee (PITAC) recommended significant increases in support for basic research in: Software, Scalable Information Infrastructure, High End Computing, and Socio-Economic and Workforce Impacts, as well as support of research projects of broader scope and visionary "Expeditions to the 21st Century" to explore new ways that computing could benefit our world.

Although the focus of the enhanced DOE program is on solving mission critical problems in scientific computing, this program will make significant contributions to the Nation's Information Technology Basic Research effort just as previous DOE mission-related research efforts have led to DOE's leadership in this field. In particular, the enhanced MICS subprogram will place emphasis on software research to improve the performance of high-end computing as well as research on the human-computer interface and on information management and analysis techniques. In addition, through NERSC and the Advanced Computing Research Facilities, the enhanced MICS subprogram will provide the most powerful high-end computers available to the Nation's scientific and engineering communities.

## Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $47,000 for estimated contractor security clearances in FY 2000 and FY 2001 within this decision unit.

## Workforce Development

The R&D Workforce Development mission is to ensure the supply of computational science and PhD level scientists for the Department and the Nation through graduate student and post doctoral research support. In FY 1999, this program will support 855 graduate students and post doctoral investigators, of which 500 will be supported at Science user facilities.

ASCR will continue the Computational Science Graduate Fellowship Program with the successful appointment of 10 new students to support the next generation of leaders in computational science.

## Funding Profile

(dollars in thousands)

| | FY 1999 Current Appropriation | FY 2000 Original Appropriation | FY 2000 Adjustments | FY 2000 Current Appropriation | FY 2001 Request |
|---|---|---|---|---|---|
| Advanced Scientific Computing Research | | | | | |
| Mathematical, Information, and Computational Sciences | 135,364 | 123,000 | -3,929 | 119,071 | 169,682 |
| Laboratory Technology Research | 15,721 | 9,000 | -188 | 8,812 | 12,288 |
| Advanced Energy Projects | 2,427 | 0 | 0 | 0 | 0 |
| Subtotal, Advanced Scientific Computing Research | 153,512 | 132,000 | -4,117 | 127,883 | 181,970 |
| Use of Prior Year Balances | -1,573[a] | 0 | 0 | 0 | 0 |
| General Reduction | 0 | -2,694 | 2,694 | 0 | 0 |
| Contractor Travel | 0 | -988 | 988 | 0 | 0 |
| Omnibus Rescission | 0 | -435 | 435 | 0 | 0 |
| Total, Advanced Scientific Computing Research | 151,939[b] | 127,883 | 0 | 127,883 | 181,970 |

**Public Law Authorization:**

Public Law 95-91, "Department of Energy Organization Act"

Public Law 103-62, "Government Performance Results Act of 1993"

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $3,735,000 which has been transferred to the SBIR program and $224,000 which has been transferred to the STTR program.

## Funding by Site

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Albuquerque Operations Office | | | | | |
| Los Alamos National Laboratory | 15,206 | 11,873 | 10,560 | -1,313 | -11.1% |
| National Renewable Energy Laboratory | 127 | 0 | 0 | 0 | 0.0% |
| Sandia National Laboratories | 5,651 | 4,798 | 4,705 | -93 | -1.9% |
| Total, Albuquerque Operations Office | 20,984 | 16,671 | 15,265 | -1,406 | -8.4% |
| Chicago Operations Office | | | | | |
| Ames Laboratory | 2,239 | 1,672 | 1,571 | -101 | -6.0% |
| Argonne National Laboratory | 19,032 | 12,187 | 11,958 | -229 | -1.9% |
| Brookhaven National Laboratory | 2,023 | 1,811 | 1,504 | -307 | -17.0% |
| Fermi National Accelerator Laboratory | 213 | 60 | 200 | +140 | +233.3% |
| Princeton Plasma Physics Laboratory | 121 | 45 | 200 | +155 | +344.4% |
| Chicago Operations Office | 19,746 | 11,001 | 10,265 | -736 | -6.7% |
| Total, Chicago Operations Office | 43,374 | 26,776 | 25,698 | -1,078 | -4.0% |
| Oakland Operations Office | | | | | |
| Lawrence Berkeley National Laboratory | 57,969 | 53,865 | 64,457 | +10,592 | +19.7% |
| Lawrence Livermore National Laboratory | 3,620 | 3,210 | 3,160 | -50 | -1.6% |
| Stanford Linear Accelerator Center | 1,052 | 375 | 450 | +75 | +20.0% |
| Oakland Operations Office | 5,176 | 2,474 | 2,179 | -295 | -11.9% |
| Total, Oakland Operations Office | 67,817 | 59,924 | 70,246 | +10,322 | +17.2% |
| Oak Ridge Operations Office | | | | | |
| Oak Ridge Inst. For Science and Education | 169 | 20 | 20 | 0 | 0.0% |
| Oak Ridge National Laboratory | 13,392 | 7,584 | 6,719 | -865 | -11.4% |
| Thomas Jefferson National Accelerator Facility | 151 | 50 | 200 | +150 | +300.0% |
| Oak Ridge Operations Office | 17 | 42 | 0 | -42 | -100.0% |
| Total, Oak Ridge Operations Office | 13,729 | 7,696 | 6,939 | -757 | -9.8% |
| Richland Operations Office | | | | | |
| Pacific Northwest National Laboratory | 4,312 | 2,602 | 2,210 | -392 | -15.1% |
| Washington Headquarters | 3,296 | 14,214 | 61,612 | +47,398 | +333.5% |
| Subtotal, Advanced Scientific Computing Research | 153,512 | 127,883 | 181,970 | +54,087 | +42.3% |
| Adjustment | -1,573[a] | 0 | 0 | 0 | 0.0% |
| Total, Advanced Scientific Computing Research | 151,939[b] | 127,883 | 181,970 | +54,087 | +42.3% |

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $3,735,000 which has been transferred to the SBIR program and $224,000 which has been transferred to the STTR program.

# Site Description

## Ames Laboratory

Ames Laboratory is a Multiprogram Laboratory located on 10 acres in Ames, Iowa. The MICS subprogram at Ames Laboratory conducts research in the materials scientific application pilot project, which focuses on applying advanced computing to problems in microstructural defects, alloys, and magnetic materials, and in computer science. The LTR subprogram at Ames conducts research in the physical, chemical, materials, mathematical, engineering, and environmental sciences through cost-shared collaborations with industry.

## Argonne National Laboratory

Argonne National Laboratory (ANL) in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. The MICS subprogram at ANL conducts basic research in mathematics and computer science, as well as research in advanced computing software tools and collaboratory tools. ANL also participates in several scientific application and collaboratory pilot projects as well as supporting an advanced computing research facility. The Advanced Computing Research Facility (ACRF) at ANL focuses on advanced computers in the IBM-SP family of technologies as well as the interaction of those architectures with advanced visualization hardware. The LTR subprogram at ANL conducts research motivated by practical energy payoffs through cost-shared collaborations with industry. The areas emphasized in the research portfolio are chemistry of ceramic membranes, separations technology, near-frictionless carbon coatings, and advanced methods for magnesium production.

## Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. The LTR subprogram at BNL conducts research motivated by practical energy payoffs through cost-shared collaborations with industry. The areas emphasized in the research portfolio are materials for rechargeable lithium batteries, sensors for portable data collection, catalytic production of organic chemicals, and DNA damage responses in human cells.

## Fermi National Accelerator Laboratory (Fermilab)

Fermilab is located on a 6,800-acre site about 35 miles west of Chicago, Illinois. The LTR subprogram at Fermilab conducts research in areas such as: superconducting magnet research, design and development, detector development and high-performance computing through cost-shared collaborations with industry.

## Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory (LBNL) is a Multiprogram Laboratory located in Berkeley, California. The Laboratory is on a 200 acre site adjacent to the Berkeley campus of the University of California. The MICS subprogram at LBNL conducts basic research in the mathematics and computer science, as well as research in advanced computing software tools and collaboratory tools. LBNL participates in several scientific application and collaboratory pilot projects as well as supporting an advanced computing research facility. The Advanced Computing Research Facility (ACRF) at LBNL currently focuses on very large scale computing on hardware in the T3E architecture from SGI-Cray including issues of distributing jobs over all the processors efficiently and the associated system management issues. LBNL manages the Energy Sciences Network (ESnet). ESnet is one of the world's most effective and progressive science-related computer networks that provides worldwide access and communications to Office of Science (SC) facilities. In 1996, the National Energy Research Scientific Computing Center (NERSC) was moved from the Lawrence Livermore National Laboratory to LBNL. NERSC provides a range of high-performance, state-of-the-art computing resources that are a critical element in the success of many SC research programs. The LTR subprogram at LBNL conducts research motivated by practical energy payoffs through cost-shared collaborations with industry. The areas emphasized in the research portfolio are molecular lubricants for computers, advanced material deposition systems, screening novel anti-cancer compounds, and innovative membranes for oxygen separation.

## Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL) is a Multiprogram Laboratory located on a 821 acre site in Livermore, California. The MICS subprogram at LLNL involves significant participation in the advanced computing software tools program as well as basic research in applied mathematics.

## Los Alamos National Laboratory

Los Alamos National Laboratory (LANL) is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. The Mathematical Information and Computational Sciences (MICS) subprogram at LANL conducts basic research in the mathematics and computer science and in advanced computing software tools. LANL also participates in several scientific application and collaboratory pilot projects as well as supporting an advanced computing research facility. The Advanced Computing Research Facility (ACRF) at LANL focuses on a progression of technologies from SGI - Cray involving Origin 2000 Symmetric Multiprocessor Computers linked with HiPPI crossbar switches. This series of research computers has been given the name "Nirvana Blue."

## Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education (ORISE) is located on 150 acres in Oak Ridge, Tennessee. ORISE provides support for education activities funded within the ASCR program.

## Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL) is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The MICS subprogram at ORNL conducts basic research in the mathematics and computer science, as well as research in advanced computing software tools and collaboratory tools.

ORNL also participates in several scientific application and collaboratory pilot projects. The LTR subprogram at ORNL conducts research motivated by practical energy payoffs through cost-shared collaborations with industry. The areas emphasized in the research portfolio are high temperature superconducting wire, microfabricated instrumentation for chemical sensing, and radioactive stents to prevent reformation of arterial blockage.

## Pacific Northwest National Laboratory

Pacific Northwest National Laboratory (PNNL) is a Multiprogram Laboratory located on 640 acres at the Department's Hanford site in Richland, Washington. The MICS subprogram at PNNL conducts basic research in the mathematics and computer science, as well as research in advanced computing software tools and collaboratory tools. PNNL also participates in several scientific application pilot projects. The LTR subprogram at PNNL conducts research motivated by practical energy payoffs through cost-shared collaborations with industry. The areas emphasized in the research portfolio are mathematical simulation of glass production, interactions of biological polymers with model surfaces, and characterization of micro-organisms in environmental samples.

## Princeton Plasma Physics Laboratory

The Princeton Plasma Physics Laboratory (PPPL), a laboratory located in Plainsboro, New Jersey, is dedicated to the development of magnetic fusion energy. The LTR subprogram at PPPL conducts research in areas that include the plasma processing of semiconductor devices and the study of beam-surface interactions through cost-shared collaborations with industry.

## Sandia National Laboratories

Sandia National Laboratories (SNL) is a Multiprogram Laboratory, with a total of 3,700 acres, located in Albuquerque, New Mexico, with sites in Livermore, California, and Tonapah, Nevada. The MICS subprogram at SNL conducts basic research in mathematics and computer science, as well as research in advanced computing software tools and collaboratory tools. SNL also participates in several scientific application and collaboratory pilot projects.

## Stanford Linear Accelerator Center

The Stanford Linear Accelerator Center (SLAC) is located at the edge of Silicon Valley in California about halfway between San Francisco and San Jose on 426 acres of Stanford University land. The LTR subprogram at SLAC conducts research in areas such as advanced electronics, large-scale ultra-high vacuum systems, radiation physics and monitoring, polarized and high-brightness electron sources, magnet design and measurement, and controls systems through cost-shared collaborations with industry.

## Thomas Jefferson National Accelerator Facility

The Thomas Jefferson National Accelerator Facility (TJNAF) is a basic research laboratory located on a 200 acre site in Newport News, Virginia. The LTR subprogram at the TJNAF conducts research in such areas as accelerator and detector engineering, superconducting radiofrequency technology, speed data acquisition, and liquid helium cryogenics through cost-shared collaborations with industry.

## All Other Sites

The ASCR program funds research at 71 colleges/universities located in 24 states supporting approximately 117 principal investigators. Also included are funds for research awaiting distribution pending completion of peer review results.

A number of enabling technology centers will be established at laboratories and/or universities. Specific site locations will be determined as a result of competitive selection. These centers will focus on specific software challenges confronting users of terascale computers.

# Mathematical, Information, and Computational Sciences

## Mission Supporting Goals and Objectives

The Mathematical, Information, and Computational Sciences (MICS) subprogram is responsible for carrying out the primary mission of the ASCR program: discovering and developing the advanced computing and communications tools and operating the high performance computing and network facilities that researchers need to analyze, model, simulate, and — most importantly — predict complex phenomena of importance to the Office of Science and to the Department of Energy. The MICS subprogram supports fundamental research and research facilities in all of the areas in which MICS supports research:

- **Applied Mathematics.** This includes research on the underlying mathematical understanding and numerical algorithms to enable effective description and prediction of physical systems such as fluids, magnetized plasmas, or protein molecules. This includes, for example, methods for solving large systems of partial differential equations on parallel computers, techniques for choosing optimal values for parameters in large systems with hundreds to hundreds of thousands of parameters, improving our understanding of fluid turbulence, and developing techniques for reliably estimating the errors in simulations of complex physical phenomena.
- **Computer Science.** This includes research in computer science to enable large scientific applications through advances in massively parallel computing such as very lightweight operating systems for parallel computers, distributed computing such as development of the Parallel Virtual Machine (PVM) software package which has become an industry standard, and large scale data management and visualization. The development of new computer and computational science techniques will allow scientists to use the most advanced computers without being overwhelmed by the complexity of rewriting their codes every 18 months.
- **Networking.** This includes research in high performance networks and information surety required to support high performance applications – protocols for high performance networks, methods for measuring the performance of high performance networks, and software to enable high speed connections between high performance computers and networks. The development of high speed communications and collaboration technologies will allow scientists to view, compare, and integrate data from multiple sources remotely.

MICS also operates supercomputer and network facilities that are available to researchers 24 hours a day, 365 days a year. The requirements far exceed the current state-of-the-art; furthermore, the requirements far exceed the tools that the commercial marketplace will deliver. For this reason, the MICS subprogram must not only support basic research in the areas listed above, but also the development of the results from this basic research into software usable by scientists in other disciplines; and partnerships with users to test the usefulness of the research. These partnerships with the scientific disciplines are critical because they test the usefulness of current advanced computing research, enable MICS to transfer the results of this research to scientists in the disciplines, and help define promising areas for future research. This integrated approach is critical for MICS to succeed in providing the extraordinary computational and communications tools that DOE's civilian programs need to carry out their missions.

## Performance Measures

- Facilities, including the National Energy Research Scientific Computing Center (NERSC) and ESnet, will be operated within budget and successfully meet user needs and satisfy overall SC program requirements where, specifically, NERSC will deliver 3.6 Teraflop capability by the end of FY 2001 to support DOE's science mission.
- Conduct regular peer review and merit evaluation based on the principles set down in 10 CFR Part 605 for grants and cooperative agreements, with all research projects reviewed at least once and no project extending more than four years without review.
- Support the Computational Science Graduate Fellowship Program with the successful appointment of 10 new students to support the next generation of leaders in computational science for DOE and the Nation.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Mathematical, Computational, and Computer Sciences Research | 48,896 | 46,086 | 73,030 | +26,944 | +58.5% |
| Advanced Computation, Communications Research and Associated Activities | 86,468 | 69,996 | 92,441 | +22,445 | +32.1% |
| SBIR/STTR | 0[a] | 2,989 | 4,211 | +1,222 | +40.9% |
| Total, Mathematical, Information, and Computational Sciences | 135,364 | 119,071 | 169,682 | +50,611 | +42.5% |

[a] Excludes $3,274,000 which has been transferred to the SBIR program and $196,000 which has been transferred to the STTR program.

## Detailed Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |

**Mathematical, Computational, and Computer Sciences Research**

- **Applied Mathematics:** Research on the underlying mathematical understanding and numerical algorithms to enable effective description and prediction of physical systems. Research in applied mathematics is critical to the DOE because of the potential of improved mathematical techniques to enable large computational simulations. In fact, the contribution of improved mathematical methods to advancing computer simulation exceeds the contribution due to speedup in the underlying hardware. This activity supports research at DOE laboratories, universities, and private companies. Many of the projects supported by this activity are partnerships between researchers at universities and DOE laboratories. To accomplish its goals, the program supports research in a number of areas including: Mathematical Physics including string theory, superstring theory, geometry of space-time, and quantum effects; Ordinary and Partial Differential Equations including numerical methods, high performance algorithms, massively parallel algorithms, novel gridding schemes, numerical linear algebra, iterative methods, sparse solvers, and dense solvers; Control Theory including differential-algebraic systems, order reduction, queuing theory; Shock Wave Theory systems, multipole expansions, mixed elliptic-hyperbolic problems, including hyperbolic and wavelet transforms; Fluid Dynamics including compressible, incompressible and reacting flows, turbulence modeling, and multiphase flows; Dynamical Systems including chaos-theory and control, and bifurcation theory; Programming and Optimization including linear and nonlinear programming, interior-point methods, and discrete and integer programming; and Geometric and Symbolic Computing including minimal surfaces and automated theorem proving. The FY 2001 budget includes the continuation of work initiated in FY 1999 to develop the mathematical basis for modeling and simulating complex stochastic phenomena of the type that arise in vital DOE areas such as global climate modeling,

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| and environmental remediation. This research also provides the basis for Defense Programs' investments in understanding the predictability of stockpile stewardship simulation. The FY 2001 budget also includes an increased level of funding for the Computational Sciences Graduate Fellowship program ($2,000,000) and funds for the competitive selection (based on a solicitation notice to labs and universities) of two enabling technology centers focused on algorithms and mathematical libraries for critical DOE applications on terascale computers ($7,700,000)........................................... | 22,564 | 23,354 | 33,054 |
| ■ **Computer Science:** Research in computer science to enable large scientific applications. This activity is critical to DOE because its requirements for high performance computing significantly exceed the capabilities of computer vendors' standard products. Therefore, much of the computer science to support this scale of computation must be developed by DOE. This activity supports research in two general areas: the underlying software to enable applications to make effective use of computers with hundreds or thousands of processors as well as computers that are located at different sites; and large scale data management and visualization. The first area includes research in protocols and tools for interprocessor communication and parallel input/output (I/O) as well as tools to monitor the performance of scientific applications and advanced techniques for visualizing very large scale scientific data. This research is carried out by researchers at DOE laboratories and universities, often working together in partnerships. The enhancements to this activity in FY 2001 will permit the establishment of a small number of competitively selected enabling technology centers to address critical computer science and systems software issues for terascale computers including: scalable open source operating systems; tools for analyzing and debugging scientific simulation software that uses thousands of processors; and the development of data management and visualization software capable of handling terabyte scale data sets extracted from petabyte scale data archives. ($7,476,000) These enabling technology centers are a critical component in DOE's strategy for taking the next steps in scientific simulation and modeling. ......................................................... | 14,000 | 14,000 | 21,476 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| ■ **Advanced Computing Software Tools:** This research uses the results of fundamental research in applied mathematics and computer science to develop an integrated set of software tools that scientists in various disciplines can use to develop high performance applications (such as simulating the behavior of materials). These tools, which provide improved performance on high-end systems, are critical to the ability of scientists to attack the complex scientific and engineering problems that can only be solved with high-end computing systems. The initial goal of this program element was to develop foundational tools (math libraries, runtime systems, etc.) that will have a useful life spanning many generations of computer hardware. From the experience gained with end user application scientists applying these tools, it has become clear that to promote wide usage across the scientific community the tools must also be robust and easy to use. Since many of the tools needed in the high performance arena have no commercial market, enabling technology centers will provide a means for focused investment to deploy these tools to the scientific community. These competitively selected centers will focus research in several areas that include software frameworks, problem solving environments, distributed computing and collaboration technologies, as well as visualization and data management. A substantial increase in this effort is provided to support this goal. ......................... | 5,000 | 5,000 | 9,000 |
| ■ **Scientific Applications Pilot Projects:** This research applies computational techniques and tools developed in the Advanced Computing Software Tools effort to basic research problems in order to test the usefulness of current advanced computing research, transfer the results of this research to the scientific disciplines, and help define promising areas for future research. In FY 2000, Grand Challenge projects initiated in FY 1991 as part of DOE's component of the Federal High Performance Computing and Communications program were phased out. The FY 2001 funding for this activity will allow the initiation of a small number of new | | | |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| pilot projects. The selection of these projects will be based on open, competitive processes. These pilot projects will be tightly coupled to the enabling technology centers (described above in computer science) and advanced computing software tools to ensure that these activities are an integrated approach to the challenges of terascale simulation and modeling that DOE faces to accomplish its missions. | 7,332 | 3,732 | 9,500 |
| Total Mathematical, Computational, and Computer Sciences Research | 48,896 | 46,086 | 73,030 |
| **Advanced Computation, Communications Research, and Associated Activities** | | | |
| ■ **Networking:** Research in high performance computer networks and information security required to support high performance computer applications — protocols for high performance networks, methods for measuring the performance of high performance networks, and software to enable high speed connections between high performance computers and both local area and wide area networks. In addition, this activity supports research in network protocols that enable applications to request, and be guaranteed, minimum acceptable levels of network capability. The enhanced level of effort in this activity in FY 2001 will enable research in the high performance "middleware," software that applications need to couple effectively to advanced network services. | 4,500 | 6,000 | 7,500 |
| ■ **Collaboratory Tools:** This research uses the results of fundamental research on computer science and networking to develop an integrated set of software tools to enable scientists to remotely access and control facilities and share data in real time. These tools are necessary to provide a new way of organizing and performing scientific work that offers the potential for increased productivity and efficiency. This research includes, for example, developing and demonstrating an open, scalable approach to application level security in widely distributed, open network environments that can be used by all the collaboratory tools as well as by the advanced computing software tools whenever access control and authentication are issues. Having demonstrated feasibility of the security architecture on a small scale, an additional investment is needed to support the integration of | | | |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| collaboratory tools with advanced networking services in a research setting. In this way, security features can be integrated into more end user applications or collaboratory tools. In addition, all these can be demonstrated on a large user base. Other examples of research in collaboratory tools include the development of a modular electronic notebook prototype for the sharing of scientific results, data from scientific instruments and design of scientific procedures; and the development of tools to manage distributed collaborations where videoconferencing, whiteboards and other shared applications are important. Shared controls for remote, collaborative control of visualizations are also being investigated. | 3,000 | 3,000 | 5,600 |

- **National Collaboratory Pilot Projects:** R&D to test, validate, and apply collaboratory tools in partnership with other DOE programs. It is important to demonstrate and test the benefits of collaboratory tools technology in order to promote its widespread use. The two continuing pilot projects are: (1) the Materials MicroCharacterization Collaboratory, a partnership with the Basic Energy Sciences program and Energy Efficiency and Renewable Energy to provide remote access to facilities located at Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory, Argonne National Laboratory, and the National Institute of Standards and Technology, and the University of Illinois for electron beam microcharacterization of materials; and (2) the Diesel Combustion Collaboratory, a partnership with Basic Energy Sciences, Energy Efficiency and Renewable Energy, and three U.S. manufacturers of diesel engines, to link researchers at Sandia National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, and the University of Wisconsin with researchers at industrial laboratories in Indiana and Michigan to develop the next generation of clean diesel engines. As communications technologies and middleware developments converge and lead to new services, a closer coupling needs to be made to the end scientific applications. Hence an increase is made for R&D to test, validate, and apply wide area data intensive collaborative computing technologies in partnerships between end user application scientists, developers of collaboration tools and other middleware, and network researchers. These

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| partnerships will be focused to develop user environments where collaboration is ubiquitous and distributed computing is seamless and transparent for DOE mission applications such as High Energy and Nuclear Physics Data, remote visualization of simulation results, and advanced collaboratories. | 3,000 | 5,000 | 11,000 |
| ■ **National Energy Research Scientific Computing Center (NERSC):** NERSC, located at LBNL, provides high performance computing for investigators supported by the Office of Science. The Center serves 2,000 users working on about 700 projects; 35 percent of users are university based, 60 percent are in National Laboratories, and 5 percent are in industry. NERSC provides a spectrum of supercomputers offering a range of high performance computing resources and associated software support. The two major computational resources at NERSC are a 512 processor Cray T3E computer and a large IBM SP computer whose initial installation was completed in early FY 2000 in a fully competitive procurement. The additional funding in FY 2001 will enable this computer to be enhanced to over 5 teraflops peak performance. This represents nearly a 40% increase over the capability that would have been attainable without the increase in funding. These computational resources will be integrated by a common high performance file storage system that facilitates interdisciplinary collaborations Related requirements for capital equipment and general plant projects (GPP) funding are also supported.. | 26,500 | 26,500 | 32,278 |
| ■ **Advanced Computing Research Facilities (ACRFs):** ACRFs support advanced computational hardware testbeds for scientific application pilot projects and fundamental research in applied mathematics and computer science. ACRFs are located at Los Alamos National Laboratory (Nirvana Blue partnership with the DOE Biological and Environmental Research (BER) program and Defense Programs (DP), based on SGI/Cray Technology); Argonne National Laboratory (IBM-SP); and Lawrence Berkeley National Laboratory (SGI/Cray T3E and IBM SP). Smaller evaluation efforts based on experimental clusters of Compaq-Alpha technology and Intel based processors are supported at ORNL and ANL. Because many of the issues to be investigated only appear in the computer systems at | | | |

| | (dollars in thousands) | |
|---|---|---|
| FY 1999 | FY 2000 | FY 2001 |

significantly larger scale than the computer manufacturers' commercial design point, these facilities must procure the largest scale systems that can be afforded and develop software to manage and make them useful. In addition, the ACRFs, taken together, must have a full range of different computer architectures to enable comparison and reduce overall program risk. These all involve significant research efforts, often in partnership with the vendors to resolve issues including operating system stability and performance, system manageability and scheduling, fault tolerance and recovery, and details of the interprocessor communications network. Therefore, all of these systems are managed as research programs and not as information technology investments. Related capital equipment needs such as high speed disk storage systems, archival data storage systems and high performance visualization hardware are also supported. An additional $2,027,000 will allow for experiments with one additional computer architecture for a high-priority DOE application. The site will be determined competitively. 20,079 13,749 15,776

- **Energy Sciences Network (ESnet):** ESnet provides worldwide access to the Office of Science facilities, including: advanced light sources; neutron sources; particle accelerators; fusion reactors; spectrometers; ACRFs; and other leading-edge science instruments and facilities. ESnet provides the communications fabric that links DOE researchers to one another and forms the basis for fundamental research in networking, enabling R&D in collaboratory tools, and applications testbeds such as the national collaboratory pilot projects. To provide these facilities, ESnet management at LBNL contracts with commercial vendors for advanced communications services including Asynchronous Transfer Mode (ATM) and Wave Division Multiplexing (WDM). ESnet management provides system integration to provide a uniform interface to these services for DOE laboratories. In addition, ESnet management is responsible for the interfaces between the network fabric it provides and the worldwide Internet including the University Corporation for Advanced Internet Development (UCAID) Abilene network that provides high performance connections to many research universities. One

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| reason that ESnet, in the words of the 1998 external review committee, is able to provide the capabilities and services to its users "at significantly lower budgets than other agencies" is its management structure with strong user and site coordination committees. This management structure is built on DOE's experience in operating large user facilities. The enhanced funding in FY 2001 will support an advanced network testbed to enable research in collaboratory tools and pilots as well as the increases in bandwidth needed to support terascale computers and the next generation of petabyte/year scale experimental facilities. Related capital equipment needs are also supported such as high speed network routers, ATM switches, and network management and testing equipment. | 14,787 | 15,747 | 20,287 |
| ■ **Next Generation Internet (NGI):** This program focused on goals of the government-wide program and supported efforts to develop, test, and validate networking technologies that DOE mission-critical applications require. Core aspects of this long-standing research are supported within the MICS subprogram as they have been since the beginning of the HPCC program in FY 1991 | 14,602 | 0 | 0 |
| Total, Advanced Computation, Communications Research, and Associated Activities | 86,468 | 69,996 | 92,441 |

**SBIR/STTR**

| | | | |
|---|---|---|---|
| ■ In FY 1999, $3,274,000 and $196,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirement for the continuation of the SBIR and STTR programs. | 0 | 2,989 | 4,211 |
| Total, Mathematical, Information, and Computational Sciences | 135,364 | 119,071 | 169,682 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Mathematical, Computational, and Computer Sciences Research** | |
| ■ Increase in the Computational Sciences Graduate Fellowship program and funds for the competitive selection of two enabling technology centers focused on algorithms and mathematical libraries for critical DOE applications on terascale computers. | +9,700 |
| ■ Increase in computer science for enabling technology centers - a critical component in DOE's strategy for taking the next steps in computational modeling and simulation. | +7,476 |
| ■ Increase in advanced computing software tools for enabling technology centers, for a focused investment to deploy tools to the scientific community. | +4,000 |
| ■ Increase in scientific applications pilot projects to allow the initiation of several new pilot projects that will be tightly coupled to the enabling technology centers in applied mathematics and computer science. | +5,768 |
| Total Mathematical, Computational, and Computer Sciences Research | +26,944 |
| **Advanced Computation, Communications Research, and Associated Activities** | |
| ■ Increase in networking to enable research in the high performance "middleware" software that applications need to couple effectively to advanced network services. | +1,500 |
| ■ Increase in collaboratory tools to support the integration of collaboratory tools with advanced networking services in a research setting. | +2,600 |
| ■ Increase in national collaboratory pilot projects to test, validate, and apply collaboratory tools in partnership with other DOE programs. | +6,000 |
| ■ Increase in NERSC funding for computer enhancement. | +5,778 |
| ■ Increase in support for Advanced Computing Research Facilities (ACRFs) | +2,027 |
| ■ Increase in support of ESnet operations for an advanced network testbed and access to multi-teraflop computers. | +4,540 |
| Total, Advanced Computation, Communications Research, and Associated Activities | +22,445 |
| **SBIR/STTR** | |
| ■ Increase in SBIR/STTR due to increase in operating expenses. | +1,222 |
| Total Funding Change, Mathematical, Information, and Computational Sciences | +50,611 |

# Laboratory Technology Research

## Mission Supporting Goals and Objectives

The mission of the Laboratory Technology Research (LTR) subprogram is to support high risk, energy related research that advances science and technology to enable applications that could significantly impact the Nation's energy economy. LTR fosters the production of research results motivated by a practical energy payoff through cost-shared collaborations between the Office of Science (SC) laboratories and industry.

An important component of the Department's strategic goals is to ensure that the United States maintains its leadership in science and technology. LTR is the lead program in the Office of Science for leveraging science and technology to advance understanding and to promote our country's economic competitiveness through cost-shared partnerships with the private sector.

The National Laboratories under the stewardship of the Office of Science conduct research in a variety of scientific and technical fields and operate unique scientific facilities. Viewed as a system, these ten laboratories — Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Princeton Plasma Physics Laboratory, Stanford Linear Accelerator Center, and Thomas Jefferson National Accelerator Facility — offer a comprehensive resource for research collaborations. The major component of the LTR research portfolio consists of investments at these laboratories to conduct research that benefits all major stakeholders — the DOE, the industrial collaborators, and the Nation. These investments are further leveraged by the participation of an industry partner, using Cooperative Research and Development Agreements (CRADAs). Another LTR program component provides rapid access by small business to the research capabilities at the SC laboratories through agile partnership mechanisms including personnel exchanges and technical consultations with small business. The LTR subprogram currently emphasizes three critical areas of DOE mission-related research: advanced materials processing and utilization, intelligent processes and controls, and energy-related applications of biotechnology.

## Funding Schedule

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Laboratory Technology Research........... | 12,753 | 8,578 | 11,963 | +3,385 | +39.5% |
| SBIR/STTR .......................................... | 0[a] | 234 | 325 | +91 | +38.9% |
| Congressional Direction ........................ | 2,968 | 0 | 0 | 0 | 0.0% |
| Total, Laboratory Technology Research.. | 15,721 | 8,812 | 12,288 | +3,476 | +39.4% |

[a] Excludes $399,000 which has been transferred to the SBIR program and $24,000 which has been transferred to the STTR program.

## Detailed Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Laboratory Technology Research** | | | |
| ■ This activity supports research to advance the fundamental science at the Office of Science laboratories toward innovative energy applications. Through CRADAs, the SC laboratories enter into cost-shared research partnerships with industry, typically for a period of three years, to explore energy applications of research advances in areas of mission relevance to both parties. The research portfolio consists of approximately 70 projects and emphasizes the following topics: advanced materials processing and utilization, intelligent processes and controls, and energy-related applications of biotechnology. Efforts underway include the exploration of (1) a unique direct casting technology for production of lower-cost, better-performing titanium wire for use in the aerospace and automotive industries; (2) the identification of plants that can be used in freshwater, aquatic, and edge environments to remove contaminants from sediment, without substantial alteration of the ecosystems; and (3) the characterization of polymer composite matrix materials, using electron beam curing, to produce stronger, lighter, and more durable materials with much lower energy demands. A small but important component of this activity provides industry, particularly small businesses, with rapid access to the unique research capabilities and resources at the SC laboratories. These research efforts are usually supported for a few months to quantify the energy benefit of a specific problem posed by industry. Recent projects supported the development of (1) web-based energy performance benchmarking to improve the energy efficiency of buildings; (2) a magnetic particle process to separate selectively iron and chromium from plating tank solutions, thereby improving plating efficiency and minimizing waste disposal cost; and (3) tools for the genetic manipulation of *Streptococcus pneumoniae* to demonstrate gene function and to identify novel genetic elements in transcription, which could lead to improved antibiotics for respiratory disease. | 12,753 | 8,578 | 11,963 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **SBIR/STTR** | | | |
| In FY 1999, $399,000 and $24,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirement for the continuation of the SBIR and STTR programs......................... | 0 | 234 | 325 |
| **Congressional Direction** | | | |
| Funds the University of Southwestern Louisiana (per FY 1997 Congressional Direction)........................................... | 2,968 | 0 | 0 |
| Total, Laboratory Technology Research.................................... | 15,721 | 8,812 | 12,288 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Laboratory Technology Research** | |
| ■ Increase in multiyear technology research partnership projects.................... | +3,385 |
| **SBIR/STTR** | |
| ■ Increase in SBIR/STTR due to increase in operating expenses. .................. | +91 |
| Total Funding Change, Laboratory Technology Research ................................. | +3,476 |

# Advanced Energy Projects

## Mission Supporting Goals and Objectives

The Advanced Energy Projects (AEP) subprogram funded research that established the feasibility of novel, energy-related concepts that span the Department's energy mission and goals. Funded projects were based on innovative ideas that spanned multiple scientific and technical disciplines and did not fit into any other DOE program area. A common theme for each project was the initial linkage of new research results to an energy application with a potentially significant payoff. Typically, AEP supported projects up to a level of about $250,000 per year for a period of about 3 years. Projects were selected from proposals submitted by universities and national laboratories. Funding criteria emphasized scientific merit as judged by external peer review.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Advanced Energy Projects ..................... | 2,427 | 0 | 0 | 0 | 0.0% |
| SBIR/STTR .......................................... | 0[a] | 0 | 0 | 0 | 0.0% |
| Total, Advanced Energy Projects ............ | 2,427 | 0 | 0 | 0 | 0.0% |

## Detailed Program Justification

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 |
|---|---|---|---|
| **Advanced Energy Projects** | | | |
| ■ Support for high-risk, high-payoff research at universities and national laboratories established the feasibility of novel energy related concepts that were at an early stage of scientific definition. Final funds for these projects were provided in FY 1999.......................... | 2,427 | 0 | 0 |
| **SBIR/STTR** | | | |
| ■ In FY 1999, $62,000 and $4,000 were transferred to the SBIR and STTR programs, respectively........................... | 0 | 0 | 0 |
| Total, Advanced Energy Projects............................................ | 2,427 | 0 | 0 |

[a] Excludes $62,000 which has been transferred to the SBIR program and $4,000 which has been transferred to the STTR program.

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Advanced Energy Projects** | |
| ■ The AEP program was terminated in FY 2000. | 0 |
| Total Funding Change, Advanced Energy Projects | 0 |

# Capital Operating Expenses & Construction Summary

## Capital Operating Expenses

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| General Plant Projects...................... | 70 | 0 | 2,000 | +2,000 | +100.0% |
| Capital Equipment (total).................. | 8,798 | 6,275 | 8,775 | +2,500 | +39.8% |
| Total, Capital Operating Expenses...... | 8,868 | 6,275 | 10,775 | +4,500 | +71.7% |

## Major Items of Equipment (TEC $2 million or greater)

(dollars in thousands)

| | Total Estimated Cost (TEC) | Prior Year Approp-riations | FY 1999 | FY 2000 | FY 2001 | Accept-ance Date |
|---|---|---|---|---|---|---|
| Archival Systems Upgrade – LBNL......... | 2,000 | 0 | 0 | 2,000 | 0 | FY 2002 |
| Distributed Visualization Server – LBNL .. | 2,500 | 0 | 0 | 0 | 2,500 | FY 2001 |
| Total, Major Items of Equipment ............ | | 0 | 0 | 2,000 | 2,500 | |

# Multiprogram Energy Laboratories - Facilities Support

## Program Mission

The Multiprogram Energy Laboratories - Facilities Support (MEL-FS) program provides line item construction funding (i.e., projects with a total estimated cost of $5,000,000 or above) for general purpose facilities to support the infrastructure of the five Office of Science multiprogram national laboratories. These are: Argonne National Laboratory - East (ANL-E), Brookhaven National Laboratory (BNL), Lawrence Berkeley National Laboratory (LBNL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest National Laboratory (PNNL). These laboratories are government-owned, contractor-operated (GOCO) and have over 1,100 buildings with 14.3 million gross square feet of space and an estimated replacement value of over $9,000,000,000. Total operating funding for these laboratories is over $3,000,000,000 a year. The Office of Science manages this program to provide a comprehensive, prioritized and equitable approach to its stewardship responsibility for the general purpose support infrastructure of these laboratories.

The program provides Payments in Lieu of Taxes (PILT) as authorized by the Atomic Energy Act of 1954, as amended. These discretionary payments are made to state or local governments where the Department or its predecessor agencies have acquired property previously subject to state or local taxation. Local communities around ANL-E, BNL, and ORNL qualify for PILT.

The program also supports costs incurred for centralized Oak Ridge Operations Office (ORO) infrastructure requirements and general operating costs essential to maintaining a viable, functioning operations office. Activities include roads and grounds maintenance, infrastructure maintenance, physical security, emergency management, support of the Oak Ridge Financial Service Center and other technical needs related to landlord responsibilities of the ORO.

## Program Goals

- To ensure that the support facilities at the multiprogram laboratories meet the Department's research needs in a safe, environmentally sound, and cost-effective manner primarily by refurbishing or replacing deteriorated, outmoded, unsafe, and inefficient general purpose infrastructure.
- To provide landlord support for the centralized Oak Ridge Operations Office and the Oak Ridge Reservation activities.

## Program Objectives

- To correct Environment, Safety and Health (ES&H) inadequacies.
- To reduce risk of operational interruptions due to failed support systems.
- To provide cost effective operations and reduce maintenance costs.

- To provide quality space for multiprogram research and support activities.
- To preserve the government investment in the physical plant of the multiprogram laboratories.
- To promote performance-based infrastructure management.
- To support local communities via Payments in Lieu of Taxes (PILT).
- To provide landlord support for the Oak Ridge Reservation and for the Oak Ridge Operations Office.

## Performance Measures

Performance measures related to the MEL-FS program are continuously being refined to ensure that they: 1) incorporate external/internal customer inputs; 2) drive performance; 3) address the strategic plan; and 4) focus on the effectiveness of the laboratory system. Current performance measures include:

- Support of line item construction funding to reduce risk, ensure continuity of operations, avoid or reduce costs and increase productivity. Fund highest priority needs based on scoring from Life Cycle Asset Management (LCAM) Cost-Risk-Impact Matrix.
- Overall condition of laboratory buildings. Increase the percentage of buildings rated adequate.
- Excellence in project management. Increase the percentage of projects completed within baseline cost and schedule.
- Continuity of Operations at the Oak Ridge Reservation and the Oak Ridge Operations Office. Interruptions due to infrastructure, security or emergency management system failures are minimized.
- Support of local communities. Meet, in a timely manner, DOE's obligations to local communities via Payments in Lieu of Taxes (PILT), where applicable.

## Significant Accomplishments and Program Shifts

- Progress in Line Item Projects - Four projects are scheduled for construction completion in FY 2001: the Central Supply Facility at ANL-E; the Electrical Systems Modifications - Phase I at BNL; Building 77 Rehabilitation at LBNL; and the Electrical Systems Upgrade, Phase III at ANL-E.
- The program includes funding of Oak Ridge Operations Office Site Landlord activities beginning in FY 2000.
- The direct funding for the American Museum for Science and Energy (AMSE) under the Oak Ridge Landlord activities will end in FY 2000. Museum operation is transferred to Oak Ridge National Laboratory where alternative funding mechanisms are being developed, including support by private or industrial partners, and possibly, an admission fee for adults.

# Funding Profile

(dollars in thousands)

| | FY 1999 Current Appropriation | FY 2000 Original Appropriation | FY 2000 Adjustments | FY 2000 Current Appropriation | FY 2001 Request |
|---|---|---|---|---|---|
| Multiprogram Energy Laboratories-Facilities Support | | | | | |
| Multiprogram Energy Laboratories-Facilities Support | 21,260 | 21,260 | -5 | 21,255 | 23,219 |
| Oak Ridge Landlord | 0 | 11,800 | 0 | 11,800 | 10,711 |
| Subtotal, Multiprogram Energy Laboratories-Facilities Support | 21,260 | 33,060 | -5 | 33,055 | 33,930 |
| Use of Prior Year Balances | -13 [a] | 0 | 0 | 0 | 0 |
| General Reduction | 0 | -5 | +5 | 0 | 0 |
| Total, Multiprogram Energy Laboratories-Facilities Support | 21,247 | 33,055 | 0 | 33,055 | 33,930 |

**Public Law Authorization:**
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance Results Act of 1993"

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

## Funding by Site

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Chicago Operations Office | | | | | |
| Argonne National Laboratory | 7,089 | 4,980 | 6,660 | +1,680 | +33.7% |
| Brookhaven National Laboratory | 1,349 | 6,881 | 6,659 | -222 | -3.2% |
| Chicago Operations Office | 1,160 | 1,160 | 1,160 | 0 | 0.0% |
| Total, Chicago Operations Office | 9,598 | 13,021 | 14,479 | +1,458 | +11.2% |
| Oakland Operations Office | | | | | |
| Lawrence Berkeley National Laboratory | 4,854 | 6,133 | 2,113 | -4,020 | -65.5% |
| Oak Ridge Operations Office | | | | | |
| Oak Ridge National Laboratory | 6,808 | 1,101 | 6,627 | +5,526 | +501.9% |
| Oak Ridge Operations Office | 0 | 11,800 | 10,711 | -1,089 | -9.2% |
| Total, Oak Ridge Operations Office | 6,808 | 12,901 | 17,338 | +4,437 | +34.4% |
| Washington Headquarters | 0 | 1,000 | 0 | -1,000 | -100.0% |
| Subtotal, Multiprogram Energy Laboratories - Facilities Support | 21,260 | 33,055 | 33,930 | +875 | +2.6% |
| Use of Prior Year Balances | -13 [a] | 0 | 0 | 0 | 0.0% |
| Total, Multiprogram Energy Laboratories - Facilities Support | 21,247 | 33,055 | 33,930 | +875 | +2.6% |

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

## Site Description

### Argonne National Laboratory - East

Argonne National Laboratory - East (ANL-E) in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. The laboratory consists of 122 facilities, 4.6 million gross square feet of space, with the average age of the facilities being 31 years. Approximately 29 percent of the space is considered adequate, while the remainder needs rehabilitation or replacement/demolition. The MEL-FS program is currently funding or proposes funding the following projects:

- MEL-001-06 - Central Supply Facility (TEC $5,900,000) - This project will consolidate operations currently dispersed throughout the site into one central location.

- MEL-001-09 - Fire Safety Improvements, Phase IV (TEC $8,430,000) This project will bring 30 major facilities into compliance with the Life Safety Code and the National Fire Alarm Code.

The program also provides funding through the Chicago Operations Office for Payments in Lieu of Taxes (PILT) as authorized by the Atomic Energy Act of 1954, as amended. These discretionary payments are made to state or local governments where the Department or its predecessor agencies have acquired property previously subject to state or local taxation.

### Brookhaven National Laboratory

Brookhaven National Laboratory is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. The laboratory consists of 349 facilities, 4.1 million gross square feet of space, with the average age of the facilities being 39 years. Approximately 27 percent of the space is considered adequate, while the remainder needs rehabilitation or replacement/demolition. The MEL-FS program is currently funding:

- MEL-001-04 - Electrical Systems Modifications, Phase I (TEC $5,730,000) This project will include: the replacement of and installation of new cables and underground ductbanks; the installation of a new 13.8 kV - 2.4 kV step-down transformer substation and replacement of other obsolete components.

- MEL-001-07 - Sanitary System Modifications, Phase III (TEC $6,500,000) This project will: replace or rehabilitate approximately 9,900 feet of existing deteriorated (8 to 20 inch) sewer piping; replace the sewage digester; connect five facilities to the sanitary system; and make other modifications to reduce discharges to the environment.

- MEL-001-13 Groundwater and Surface Water Protection (TEC $6,050,000) This proposed new start for FY 2001 will implement a backlog of ground and surface water protection projects which are commitments to regulators. These include: proper closure of inactive supply and injection wells; runoff control for the surplus material storage yard; containment and runoff control for the radioactive material storage yard; replacement of 12 hydraulic elevator cylinders; removal of 22 underground fuel oil tanks; replacement of radioactive waste tanks with secondarily contained tanks.

- MEL-001-16 Electrical Systems Modifications, II (TEC $6,770,000) This proposed new start for FY 2001 will be the second phase of the modernization and refurbishment of the laboratory's deteriorating 50 year-old electrical infrastructure. The project includes: installation of two new 13.8 kV feeders to provide alternate sources to existing, aged feeders; installation of additional underground ductbanks to support a new 13.8 kV feeder; replacement of 2.4 kV switchgear to increase system reliability and safety; reconditioning of 50 480-volt circuit breakers including replacing obsolete trip units with modern, solid-state trip devices; and the retrofit of 10 13.8 kV air breakers with new vacuum technology.

The program also provides funding through the Chicago Operations Office for Payments in Lieu of Taxes (PILT) as authorized by the Atomic Energy Act of 1954, as amended. These discretionary payments are made to state or local governments where the Department or its predecessor agencies have acquired property previously subject to state or local taxation.

## Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The laboratory is on a 200 acre site adjacent to the Berkeley campus branch of the University of California. The laboratory consists of 118 facilities, 1.6 million gross square feet of space, with the average age of the facilities being 34 years. Approximately 19 percent of the space is considered adequate, while the remainder needs rehabilitation or replacement/demolition. The MEL-FS program is currently funding or proposes to fund the following projects:

- MEL-001-05 - Building 77-Rehabilitation of Building Structure and Systems (TEC $8,000,000) This project will correct seismic deficiencies and refurbish and upgrade the electrical and mechanical systems to facilitate the high precision processes currently being performed in the facility.

- MEL-001-12 - Site-wide Water Distribution System Upgrade (TEC $8,300,000) This proposed new start for FY 2001 will rehabilitate the Lab's High Pressure Water (HPW) System to include: replacement of all 1.4 km of cast iron pipe with ductile iron pipe; installing cathodic protection; replacing and adding pressure reducing stations to prevent excessive system pressure at lower lab elevations; adding an emergency fire water tank to serve the East Canyon; and providing the two current emergency fire water tanks with new liners and seismic upgrades.

## Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL) is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The laboratory consists of 466 facilities, 3.4 million gross square feet of space, with the average age of the facilities being 37 years. Approximately 18 percent of the space is considered adequate, while the remainder needs rehabilitation or replacement/demolition. The MEL-FS program is currently funding or proposes to fund the following projects:

- MEL-001-08 Electrical Systems Upgrade (TEC $5,900,000) This project will include: replacing overhead feeders; installing advanced protective relaying capabilities at major substations; and replacing major switchgear and transformers.

- MEL-001-14 Fire Protection System Upgrade (TEC $5,920,000) This proposed new start for FY 2001 will: replace deteriorated, obsolete systems with more reliable fire alarm and suppression capabilities; replace the single 16-inch water main in the east central section of ORNL with a looped system; and extend coverage of automatic alarm systems and sprinkler systems to areas not previously served. The fire alarm receiving equipment at the site fire department headquarters will also be upgraded to ensure its reliability, modernize its technology, and meet the demands of an expanded fire alarm system network.

- MEL-001-15 Facilities HVAC Upgrade (TEC $7,100,000) This proposed new start for FY 2001 will provide improvements to aging HVAC systems (average age 38 years) located in the thirteen buildings which comprise ORNL's central research complex and additions and improvements to the chilled water distribution system. This includes: redesign of the cooling water distribution system to reduce the number of pumps required and installing more efficient pumps, thereby reducing operations and maintenance costs; installation of an 800 ft., 8-inch-diameter pipe, chill water cross-tie to Bldgs. 4501/4505 from the underground tie-line between Bldgs. 4500N/4509 to address low capacity problems in 4501/4505; installation of a 500 ft. 4-inch-diameter pipe to feed new chilled water coils in the east wing of Bldg. 3500; upgrade of the existing 50 year-old air handler with new dampers, filters, steam coils, and controls; and replacement of constant volume, obsolete air handlers in various buildings with variable air volume (VAV) improvements to more efficiently control temperature.

## Oak Ridge Operations Office

The Oak Ridge Landlord program provides for centralized Oak Ridge Operations Office (ORO) infrastructure requirements and general operating costs for activities on the Oak Ridge Reservation outside plant fences and activities to maintain a viable operations office, including maintenance of roads and grounds and other infrastructure, operation of the Emergency Management Program Office, Payments In Lieu of Taxes, physical security and support for the Oak Ridge Financial Service Center as well as other technical needs related to landlord activities.

# Multiprogram Energy Laboratories - Facilities Support

## Mission Supporting Goals and Objectives

This subprogram supports the program's goal to ensure that support facilities at the Office of Science multiprogram laboratories can meet the Department's research needs primarily by refurbishing or replacing deteriorated, outmoded, unsafe, and inefficient general purpose infrastructure. General purpose facilities are general use, service and support facilities such as administrative space, cafeterias, general office/laboratory space, utility systems, sanitary sewers, roads, etc. Less than half of the space is considered fully adequate, while the remainder needs rehabilitation or replacement/demolition. The large percentage of inadequate space reflects the age of the facilities (average age of 33 years), changing research needs that require more office space and light laboratory space, ES&H requirements and obsolete systems.

Capital investment requirements are identified in laboratory Institutional Plans that address needs through the year 2004 based on expected programmatic support. The projected needs through the period total over $450,000,000. Of this amount, 65 percent is to rehabilitate or replace buildings; 21 percent is for utility projects; and 11 percent for ES&H projects. All projects are first ranked using a prioritization model that takes into account risk, impacts, and mission need. The projects that have ES&H as the principal driver are further prioritized using the Risk Prioritization Model from the DOE ES&H and Infrastructure Management Plan process.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| General Purpose Facilities | 10,271 | 14,495 | 8,816 | -5,679 | -39.2% |
| Environment, Safety and Health | 9,829 | 4,600 | 13,243 | +8,643 | +187.9% |
| Infrastructure Support | 1,160 | 2,160 | 1,160 | -1,000 | -46.3% |
| Total, Multiprogram Energy Laboratories-Facilities Support | 21,260 | 21,255 | 23,219 | +1,964 | +9.2% |

## Detailed Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **General Purpose Facilities** | | | |
| ■ Provides funding to support the initiation of one new subproject in FY 2001 as well as the continuation of one FY 2000 subproject and the completion of three FY 1999 subprojects under the Multiprogram Energy Laboratories Infrastructure Project (MEL-001). The FY 2001 funding for a new start is for design activities for the Facilities HVAC Upgrade at ORNL ($500,000). The FY 2000 subproject is the Electrical Systems Upgrade at ORNL ($5,543,000). The FY 1999 subprojects are the Central Supply Facility at ANL-E ($660,000); the Electrical Systems Modifications, Phase I at BNL ($1,000,000), and the Rehabilitation of Building 77 at LBNL ($1,113,000)............................................................................ | 10,271 | 14,495 | 8,816 |
| **Environment, Safety and Health** | | | |
| ■ Provides funding to support the initiation of four new ES&H subprojects in FY 2001, as well as the continuation of one FY 2000 subproject under the Multiprogram Energy Laboratories Infrastructure Project (MEL-001). The FY 2001 funding for new starts is for design activities for Ground and Surface Water Protection Upgrades at BNL ($1,889,000); Fire Protection System Upgrades at ORNL ($584,000); Site-wide Water Distribution System Upgrade at LBNL ($1,000,000); and Electrical Systems Modifications, II at BNL ($770,000). The FY 2000 subproject is the Fire Safety Improvements, Phase IV at ANL-E ($6,000,000). Also supports the completion of the Sanitary System Modifications, Phase III at BNL ($3,000,000). ......................................................................... | 9,829 | 4,600 | 13,243 |
| **Infrastructure Support** | | | |
| ■ Continue meeting Payments in Lieu of Taxes (PILT) assistance requirements for communities surrounding Brookhaven National Laboratory and Argonne National Laboratory-East.... | 1,160 | 2,160 | 1,160 |

| | (dollars in thousands) | | |
| --- | --- | --- | --- |
| | FY 1999 | FY 2000 | FY 2001 |
| Total, Multiprogram Energy Laboratories - Facilities Support ......... | 21,260 | 21,255 | 23,219 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
| --- | --- |
| ▪ The increase from FY 2000 to FY 2001 for the General Purpose Facilities and the Environment, Safety and Health programs reflects the additional new project starts in FY 2001.......................................................................................................... | +2,964 |
| ▪ The decrease in the Infrastructure Support subprogram is for Payments in Lieu of Taxes (PILT) which were increased by $1,000,000 in the FY 2000 appropriation to eliminate arrearages through fiscal year 1998............................................................ | -1,000 |
| Total Funding Change, Multiprogram Energy Laboratories - Facilities Support............... | +1,964 |

# Oak Ridge Landlord

## Mission Supporting Goals and Objectives

This subprogram supports landlord responsibilities for the centralized Oak Ridge Operations Office including infrastructure of the Oak Ridge Reservation (the 24,000 acres of the Reservation outside of the Y-12 plant, ORNL, and the East Tennessee Technology Park). This includes roads and grounds maintenance, infrastructure maintenance, support of the Oak Ridge Financial Service Center, physical security, emergency management, PILT for Oak Ridge communities, and other technical needs related to landlord requirements.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Oak Ridge Landlord | 0 | 11,800 | 10,711 | -1,089 | -9.2% |

## Detailed Program Justification

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 |
|---|---|---|---|
| **Oak Ridge Landlord** | | | |
| ■ Roads, Grounds and Other Infrastructure and ES&H Improvements. | 0 | 2,200 | 2,200 |
| ■ Physical Security for the Oak Ridge Operations Office landlord responsibilities - provides for an around the clock security force. | 0 | 2,500 | 2,500 |
| ■ Emergency Management Program Office - provides for the operation of the Oak Ridge Emergency Operations Center and the Communications and Operations Center. | 0 | 1,400 | 1,400 |
| ■ Payments in Lieu of Taxes (PILT) to the City of Oak Ridge, and Anderson and Roane Counties | 0 | 1,700 | 1,700 |
| ■ American Museum of Science and Energy – supports operation of the museum. Direct support for the museum ends in FY 2000. Museum operation will be transferred to ORNL where alternative funding mechanisms are being developed, including support by private or industrial partners, and possibly an admission fee for adults. | 0 | 1,100 | 0 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| ■ Oak Ridge Financial Service Center – provides computer and systems support to the Center which serves other DOE field offices as well as Oak Ridge. | 0 | 2,000 | 2,000 |
| ■ Other Technical Support includes recurring activities such as computer and systems support for Directives and Training activities and one-time activities such as the identification, packaging, and shipment of documents relating to Human Radiation Experimentation to the National Archives for permanent storage and support for legacy legal cases. | 0 | 900 | 911 |
| Total, Oak Ridge Landlord | 0 | 11,800 | 10,711 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Oak Ridge Landlord** | |
| ■ Direct support for the American Museum of Science and Energy will end in FY 2000. Museum operation will be transferred to Oak Ridge National Laboratory which is developing alternative funding mechanisms including support by private or industrial partners, and possibly an admission fee for adults. | -1,100 |
| ■ Continue technical support at FY 2000 level of effort. | +11 |
| Total Funding Change, Oak Ridge Landlord | -1,089 |

# Capital Operating Expenses & Construction Summary

## Capital Operating Expenses

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| General Plant Projects | 0 | 300 | 200 | -100 | -33.3% |
| Capital Equipment | 0 | 100 | 325 | +225 | +225.0% |
| Total, Capital Operating Expenses | 0 | 400 | 525 | +125 | +31.3% |

## Construction Projects

(dollars in thousands)

| | Total Estimated Cost (TEC) | Prior Year Approp-riations | FY 1999 | FY 2000 | FY 2001 | Unapprop. Balance |
|---|---|---|---|---|---|---|
| Project - MEL-001 Multiprogram Energy Laboratories Infrastructure Project FY 2001 Datasheet | N/A | N/A | 14,924 | 18,351 | 22,059 | 31,427 |
| Total, MELFS Construction [a] | N/A | N/A | 20,100 [a] | 19,095 [a] | 22,059 [a] | 31,427 |

[a] Total MELFS construction, including projects fiscally completed prior to FY 2001.

# MEL-001 - Multiprogram Energy Laboratories, Infrastructure Project, Various Locations

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line in the left margin.)

## Significant Changes

Five new starts in FY 2001 include: Ground and Surface Water Protection Upgrades at Brookhaven National Laboratory, Fire Protection System Upgrades at Oak Ridge National Laboratory; Site-wide Water Distribution System Upgrade at Lawrence Berkeley National Laboratory; Facilities HVAC Upgrade at Oak Ridge National Laboratory; and Electrical Systems Modifications, II at Brookhaven National Laboratory.

## 1. Construction Schedule History

| Fiscal Quarter | | | | Total Estimated Cost ($000) | Total Project Cost ($000) |
|---|---|---|---|---|---|
| A-E Work Initiated | A-E Work Completed | Physical Construction Start | Physical Construction Complete | | |

N/A -- See subproject details

## 2. Financial Schedule

(dollars in thousands)

| Fiscal Year | Appropriations | Obligations | Costs |
|---|---|---|---|
| **Design and Construction** | | | |
| FY 1998 | 7,259 | 7,259 | 2,358 |
| FY 1999 | 14,924 | 14,911 | 9,561 |
| FY 2000 | 18,351 | 18,351 | 17,789 |
| FY 2001 | 22,059 | 22,059 | 22,567 |
| FY 2002 | 20,150 | 20,150 | 19,564 |
| FY 2003 | 11,277 | 11,277 | 14,546 |
| FY 2004 | 0 | 0 | 7,185 |
| FY 2005 | 0 | 0 | 437 |

## 3. Project Description, Justification and Scope

This project funds two types of subprojects:

- Projects that renovate or replace inefficient and unreliable general purpose facilities (GPF) including general use, service and support facilities such as administrative space, cafeterias, utility systems, and roads; and

- Projects to correct ES&H deficiencies including fire safety improvements, sanitary system upgrades and electrical system replacements.

General Purpose Facility Projects:

a. Subproject 01 - Upgrade Steam Plant, ORNL

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 5,300 | 3,400 | 1,900 | 0 | 0 | 0 | 1Q 1998 - 4Q 1999 |

This project upgraded the ORNL steam plant by adding a new steam boiler of approximately 100,000 pounds per hour capacity and capable of burning both natural gas and fuel oil. The boiler was procured with all necessary ancillary equipment, such as blowers, feedwater pumps, and controls. Suitable weather protection is provided.

This project was needed because of the age of the five existing boilers. Three are 46 years old, one is 44 years old, and the fifth is 32 years old. The new boiler capacity allows decreased firing time on the oldest boilers and extends their useful life. In addition, the new boiler improves the efficiency of the steam plant.

b. Subproject 04 - Electrical Systems Modifications, Phase I (BNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 5,730 | 0 | 849 | 3,881 | 1,000 | 0 | 2Q 1999 - 4Q 2001 |

This project is the first phase of a planned modernization and refurbishment of the Laboratory's electrical infrastructure. The project provides for the replacement of 30 to 50 year old deteriorating underground electrical cables, the addition of underground ductbanks to replace damaged portions and support new cabling, the installation of a new 13.8 kV - 2.4 kV step-down transformer substation to address capacity and operational problems, and the retrofitting/reconditioning of switchgear power circuit breakers.

c. Subproject 05 - Bldg. 77 - Rehabilitation of Building Structure and Systems (LBNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 8,000 | 0 | 754 | 6,133 | 1,113 | 0 | 2Q 1999 - 4Q 2001 |

This project will rehabilitate Building 77's structural system to restore lateral force resistance and arrest differential foundation settlement, and will modernize architectural, mechanical, and electrical systems. These upgrades will restore this 33 year-old, 68,000 sq.ft. building to acceptable seismic performance; provide environmental controls appropriate to precision fabrication processes; increase the reliability and maintainability of building systems; provide flexibility to meet future challenges; and extend building life by 40 years and building systems by 20 to 25 years.

d. Subproject 06 - Central Supply Facility (ANL-E)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 5,900 | 0 | 1,860 | 3,380 | 660 | 0 | 2Q 1999 - 4Q 2001 |

This project includes a 22,000 sq.ft. addition to the Transportation and Grounds Facility (Bldg. 46) along with remodeling of 3,500 sq.ft. of space in the existing Transportation and Grounds Facility. The project will result in economies and efficiencies by providing a highly efficient and cost-effective consolidated facility to meet the missions of the Materials Group and the Property Group of ANL-East and will eliminate the need for 89,630 square feet of substandard (50 year-old) space in six buildings which will be demolished (Bldgs. 4, 5, 6, 26, 27, and 28). The Materials Group receives, sorts, stores, retrieves, and distributes the majority of all materials and supplies for the Laboratory. The Property Group tags, controls, stores, and distributes excess property and precious metals for the Laboratory. This facility will contain truck docks; receiving and distribution areas; inventory control; general material storage; support and office areas; property storage; and exterior hazardous storage. This project will also eliminate 7,000 linear feet of steam supply and return lines.

e. Subproject 08 - Electrical Systems Upgrade (ORNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 5,900 | 0 | 0 | 357 | 5,543 | 0 | 3Q 2000 - 3Q 2002 |

This project will replace electrical distribution feeders and upgrade transformers and switchgear feeding research facilities and primary utility support facilities throughout the Oak Ridge National Laboratory (ORNL) complex. It will also provide advanced protective relaying and metering capabilities at major substations. The project is part of a phased infrastructure upgrade to restore the electrical distribution systems serving the ORNL. The purpose of the upgrade is to maintain a reliable source of electrical power appropriate for servicing scientific research facilities. Without the proposed upgrade, the potential for electrical faults and outages will increase as the distribution system ages, with attendant increased risk of equipment damage and the potential inability to meet laboratory programmatic goals due to downtime of critical facilities. These facilities include the central research facilities, supercomputing facility, Robotics and Process Systems facility, the central chilled water plant, and the steam plant. Also, maintenance costs involved in continued operation of the existing deteriorated system will increase as the system ages.

f. Subproject 15 – Laboratory Facilities HVAC Upgrade (ORNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 7,100 | 0 | 0 | 0 | 500 | 6,600 | 2Q 2001 – 1Q 2004 |

This project will provide improvements to aging HVAC systems (average age 38 years) located in the thirteen (13) buildings which comprise Oak Ridge National Laboratory's (ORNL's) central research complex and additions and improvements to the chiller water distribution system. This includes:
redesign of the cooling water distribution system to reduce the number of pumps required and installing more

efficient pumps, thereby reducing operations and maintenance costs; installation of an 800 ft., 8-inch-diameter pipe, chill water cross-tie to Bldgs. 4501/4505 from the underground tie-line between Bldgs. 4500N/4509 to address low capacity problems in 4501/4505; installation of a 500 ft. 4-inch-diameter pipe to feed new chilled water coils in the east wing of Bldg. 3500; upgrade of the existing 50 year-old air handler with new dampers, filters, steam coils, and controls; and replacement of constant volume, obsolete air handlers in various buildings with variable air volume (VAV) improvements to more efficiently control temperature.

ES&H Projects:

a. Subproject 02 - Electrical Systems Rehab. Phase IV, (LBNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 6,500 | 2,400 | 4,100 | 0 | 0 | 0 | 2Q 1998 - 3Q 2000 |

The Blackberry Switching Station Replacement Project is the last major planned rehabilitation to the LBNL electrical power system, in order to maintain its reliability and improve its safety. The project upgraded the existing 12 kV power system and utilized circuit breakers installed in the FY 1987 MEL-FS project improvement to the main Grizzly Substation.

The project corrected existing deficiencies in the power distribution system that serves the Blackberry Canyon Service Area. The improvements replaced the existing electrical system, which consisted of aged and underrated electrical equipment, 20 to 30 years old in many instances, which is difficult to maintain and unsafe to operate. It provided the Laboratory with increased operational flexibility as well as improvements in reliability, maintainability and safety.

b. Subproject 03 - Electrical Systems Upgrade, Phase III, (ANL-E)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 7,620 | 1,459 | 4,961 | 1,200 | 0 | 0 | 2Q 1998 - 1Q 2001 |

The project provides for the upgrade of the main electrical substation at Facility 543 and Facility 549A.

The work consists of the following items: install a new 138 kV overhead steel pole transmission line and upgrade the existing transmission line; relocate an existing transformer; upgrade existing transformers; replace existing 13.2 kV outdoor switchgear; and replace existing oil circuit breaker.

The intended project will accomplish several objectives related to system reliability, personnel safety, environmental hazards, risk reduction and system expansion.

c. Subproject 07 - Sanitary System Modifications, Phase III, (BNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 6,500 | 0 | 500 | 3,000 | 3,000 | 0 | 2Q 1999 - 2Q 2002 |

The BNL Sanitary System consists of over 20 miles of collection piping that collects sanitary waste from nearly all the BNL facilities. The collection piping transports the waste via gravity piping and lift stations to a sewage treatment plant (STP). This project is the third phase of the upgrade of the Laboratory sanitary waste system. In the first two phases, major operations of the STP were upgraded and approximately 14,000 feet of trunk sewer lines were replaced, repaired, or lined. Phase III will continue this upgrade and will replace or rehabilitate approximately 9,900 feet of existing deteriorated (8 to 20 inch) sewer piping, connect five facilities to the sanitary system by installing 7,500 feet of new sewer pipe, and two new lift stations. This will eliminate non-compliant leaching fields and cess pools, reduce non-contact cooling water flow into the sewage system by 72 million gallons per year by: diverting flow to the storm system; converting water heat exchangers to air cooled condensers; and replacing water cooled equipment in 15 buildings. The STP anaerobic sludge digester will be replaced with an aerobic sludge digester to eliminate high maintenance activity and improve performance, and install liners and modify the under drain piping in the STP sand filter beds.

d. Subproject 09 - Fire Safety Improvements, Phase IV, (ANL-E)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 8,430 | 0 | 0 | 400 | 6,000 | 2,030 | 3Q 2000 - 2Q 2003 |

This project will complete the effort of correcting known deficiencies with respect to fire detection and alarm systems; life safety and OSHA related sprinkler systems; and critical means of egress in twenty-eight (28) buildings at the Argonne National Laboratory-East (ANL-E) site. Correction of these deficiencies is required to comply with DOE Order 420.1, OSHA 1910,164, and OSHA Subpart C. These deficiencies, if uncorrected, could result in unmitigated risks of injury to personnel and/or damage to DOE property in case of fire.

e. Subproject 12 - Site-wide Water Distribution System Upgrade, (LBNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 8,300 | 0 | 0 | 0 | 1,000 | 7,300 | 2Q 2000 - 2Q 2004 |

This project will rehabilitate the Laboratory's High Pressure Water (HPW) System that supplies over 100 facilities at LBNL. The HPW System provides domestic water, fire water, treated water, cooling tower water and low conductivity water. It consists of 9.6 km of pipe (1.4 km of cast iron pipe, 6.3 km of ductile iron pipe, and 1.9 km of cement lined coated steel pipe), associated valves, pumps, fittings etc. and two 200,000 gallon emergency fire water tanks. This project will: replace all cast iron pipe, which is in imminent danger of failing, with ductile iron pipe; electrically isolate pipe and provide cathodic protection; replace leaking valves and add pressure reducing stations to prevent excessive system pressure at lower lab elevations; add an emergency fire water tank to serve the East Canyon; and provide the two current emergency fire water tanks with new liners and seismic upgrades.

f. Subproject 13 - Groundwater and Surface Water Protection Upgrades, (BNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 6,050 | 0 | 0 | 0 | 1,889 | 4,161 | 2Q 2001 - 2Q 2004 |

This project will implement a backlog of ground and surface water protection projects that are commitments to regulators. These include: proper closure of inactive supply and injection wells; runoff control for the surplus material storage yard; containment and runoff control for the radioactive material storage yard; replacement of 12 hydraulic elevator cylinders; removal of 22 underground fuel oil tanks; and other Suffolk County DHS Article 12 upgrades.

g. Subproject 14 - Fire Protection System Upgrade, (ORNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 5,920 | 0 | 0 | 0 | 584 | 5,336 | 2Q 2001 - 2Q 2004 |

This project will upgrade the 36 year-old fire protection system with improved, more reliable fire alarm and suppression capabilities by: replacing deteriorated, obsolete systems; replacing the single 16-inch water main in the east central section of ORNL with a looped system (7,000 lf of 16 inch pipe); and by extending coverage of automatic alarm systems and sprinkler systems to areas not previously served. New fire alarm equipment will provide emergency responders with greatly improved annunciation of the causes and locations of alarms and will provide code compliant occupant notification evacuation alarms for enhanced life safety. It will also include timesaving, automatic diagnostic capabilities that will reduce maintenance costs. The new occupant notification systems will comply with the Americans with Disabilities Act. The fire alarm receiving equipment at the site fire department headquarters will be upgraded to ensure its reliability, modernize its technology, and meet the demands of an expanded fire alarm system network.

h. Subproject 16 – Electrical Systems Modifications II, (BNL)

| TEC | Prev. | FY 1999 | FY 2000 | FY 2001 | Outyear | Construction Start/ Completion Dates |
|---|---|---|---|---|---|---|
| 6,770 | 0 | 0 | 0 | 770 | 6,000 | 2Q 2001 – 1Q 2003 |

This project is the second phase of the modernization and refurbishment of the Laboratory's deteriorating 50 year-old electrical infrastructure. The project includes: installation of two new 13.8 kV feeders to provide alternate sources to existing, aged feeders; installation of additional underground ductbanks to support a new 13.8 kV feeder; replacement of 2.4 kV switchgear to increase system reliability/safety; reconditioning of 50 480-volt circuit breakers including replacing obsolete trip units with modern, solid-state trip devices; and the retrofit of 10 13.8 kV air breakers with new vacuum technology.

## 4. Details of Cost Estimate

N/A

## 5. Method of Performance

Design will be negotiated by architect-engineer contracts or laboratory personnel. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

## 6. Schedule of Project Funding

N/A

## 7. Related Annual Funding Requirements

N/A

# Energy Research Analyses

## Program Mission

The mission of the Energy Research Analyses (ERA) program is to evaluate the quality and impact of Department of Energy research programs and projects.

## Program Goal

Provide Department of Energy program managers and senior managers with objective assessments of research projects and programs in order to evaluate the quality and impact of these efforts, to identify undesirable duplications and gaps, and to provide analysis of key technical issues in support of long range energy research planning, science and technology planning, and technical and performance evaluation of departmental programs and objectives.

## Program Objectives

- *To Provide The Basis For Judgments on The Quality of Research And Its Impact*. Using merit review with peer evaluation for technology and research/development programs, provide departmental program managers and their superiors with detailed information about the technical strengths and weaknesses of projects that comprise the research and development (R&D) program as a basis for judgment of the quality of the research and its impact.
- *To Provide Independent Views of Future R&D Needs in Areas of Interest to The Department*. Evaluate the status of science and technology areas of potential importance to the Department's mission, and to lay out appropriate fundamental and applied research and development to hasten the advance towards potential energy applications.
- *To Develop Strategic And Performance Plans*. Use advice from outside experts, advisory committees, departmental managers, national laboratory managers, industrial scientists and managers, and officials of other government agencies to formulate strategic and performance plans for the Office of Science and for the Science and Technology business line of the Department.
- *To Contribute to DOE And Interagency Program Analysis And Planning For Government Science And Technology*. Support participation in committees, task forces, working groups, and workshops of the Department of Energy and organizations such as the National Science and Technology Council, the National Science Foundation, the National Academy of Sciences, and private sector organizations such as the Industrial Research Institute, and the Electric Power Research Institute.

## Performance Measures

- Quality and value of peer review evaluations, as indicated by satisfaction of investigators and program managers and actions taken to improve or replace projects that have significant shortcomings, and to capitalize on the strengths of stronger projects.

- Satisfaction by customer program managers with assessments of science and technology needs, as indicated by changes or additions to make DOE programs and projects more productive and relevant to DOE missions.

- Quality and acceptance of strategic and performance plans, as indicated by their use by the Director of the Office of Science and by program offices in multi-year program planning, program management, and in effectively justifying programs.

- Influence on government science and technology planning and analysis, as indicated by contributions to DOE, interagency, and outside recommendations on science policies and plans.

## Significant Accomplishments and Program Shifts

- Independent peer reviews assessed the quality and relevance of over 100 DOE projects and tasks in FY 1999.

- A new Office of Science Strategic Plan was developed in FY 1999 that will be implemented in FY 2000 to guide the Office of Science into the first quarter of the next century.

- A Department of Energy Science Portfolio was developed in FY 1999 to characterize the R&D efforts within the department with regard to basic research. This portfolio will be maintained to assist the Director of the Office of Science to better manage the Department's Science investments.

# Funding Profile

(dollars in thousands)

| | FY 1999 Current Appropriation | FY 2000 Original Appropriation | FY 2000 Adjustments | FY 2000 Current Appropriation | FY 2001 Request |
|---|---|---|---|---|---|
| Energy Research Analyses | | | | | |
| Energy Research Analyses .......... | 976 | 1,000 | -9 | 991 | 1,000 |
| Subtotal, Energy Research Analyses | 976 | 1,000 | -9 | 991 | 1,000 |
| Use of Prior Year Balances .......... | -92[a] | 0 | 0 | 0 | 0 |
| General Reduction....................... | 0 | -4 | 4 | 0 | 0 |
| Contractor Travel......................... | 0 | -5 | 5 | 0 | 0 |
| Total, Energy Research Analyses...... | 884[b] | 991 | 0 | 991 | 1,000 |

**Public Law Authorization:**
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance Results Act of 1993"

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $23,000 which has been transferred to the SBIR program and $1,000 which has been transferred to the STTR program.

# Funding by Site

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Albuquerque Operations Office | | | | | |
| Sandia National Lab/Albuquerque | 0 | 50 | 75 | +25 | +50.0% |
| Chicago Operations Office | | | | | |
| Brookhaven National Laboratory | 48 | 50 | 0 | -50 | -100.0% |
| Fermi National Accelerator Laboratory | 0 | 0 | 60 | +60 | +100.0% |
| Chicago Operations Office | 231 | 0 | 0 | 0 | 0.0% |
| Total, Chicago Operations Office | 279 | 50 | 60 | +10 | +20.0% |
| Oak Ridge Operations Office | | | | | |
| Oak Ridge National Laboratory | 0 | 40 | 40 | 0 | 0.0% |
| Oak Ridge Institute for Science and Education | 10 | 0 | 100 | +100 | +100.0% |
| Total, Oak Ridge Operations Office | 10 | 40 | 140 | +100 | +250.0% |
| Oakland Operations Office | | | | | |
| Lawrence Berkeley National Laboratory | 165 | 30 | 75 | +45 | +150.0% |
| Richland Operations Office | | | | | |
| Pacific Northwest National Laboratory | 250 | 250 | 300 | +50 | +20.0% |
| Washington Headquarters | 272 | 571 | 350 | -221 | -38.7% |
| Subtotal, Energy Research Analyses | 976 | 991 | 1,000 | +9 | +0.9% |
| Use of Prior Year Balances | -92[a] | 0 | 0 | 0 | 0.0% |
| Total, Energy Research Analyses | 884[b] | 991 | 1,000 | +9 | +0.9% |

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $23,000 which has been transferred to the SBIR program and $1,000 which has been transferred to the STTR program.

# Site Description

## Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York.

## Fermi National Accelerator Laboratory (Fermilab)

Fermilab is located on a 6,800-acre site about 35 miles west of Chicago, Illinois.

## Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The Laboratory is on a 200 acre site adjacent to the Berkeley campus of the University of California. This activity contributes to the Energy Research Analyses program's formulation of long-term plans and science policy.

## Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education (ORISE) is located on 150 acres in Oak Ridge, Tennessee.

## Oak Ridge National Laboratory

Oak Ridge National Laboratory is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. Oak Ridge National Laboratory supports the Energy Research Analyses program in technical reviews of Department research programs. This activity includes technical support for peer review assessments and other studies and workshops as requested.

## Pacific Northwest National Laboratory

Pacific Northwest National Laboratory is a Multiprogram Laboratory located on a 640 acre site at the Department's Hanford site in Richland, Washington. Pacific Northwest National Laboratory carries out research in the areas of technical planning and economic analysis to contribute to the Energy Research Analyses program's formulation of long term plans and science policy. This activity includes assessments of international basic energy science programs and private sector investments in energy R&D.

## Sandia National Laboratories

Sandia National Laboratories (SNL) is a Multiprogram Laboratory, with a total of 3,700 acres, located in Albuquerque, New Mexico, with sites in Livermore, California, and Tonapah, Nevada. Sandia National Laboratory carries out research in the areas of technical program planning and merit review practices to contribute to the Energy Research Analyses program's formulation of best practices for long term plans, science policy and peer reviews. This activity includes assessments of best practices in research and development organizations.

## All Other Sites

Includes funds for research awaiting distribution pending finalization of program office detailed planning.

# Energy Research Analyses

## Mission Supporting Goals and Objectives

The Energy Research Analyses (ERA) program assesses research projects and programs in order to judge the significance of these efforts and to identify undesirable duplications and gaps. Peer reviews of individual research projects using outside experts are performed. Technical assessments to determine the direction of future research and state-of-the-science reviews are also performed. The program also provides analyses in support of long-range energy research planning, science and technology planning, and technical evaluation of DOE programs and objectives.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Energy Research Analyses ............... | 976 | 965 | 973 | +8 | +0.8% |
| SBIR/STTR ..................................... | 0[a] | 26 | 27 | +1 | +3.8% |
| Total, Energy Research Analyses....... | 976 | 991 | 1,000 | +9 | +0.9% |

## Detailed Program Justification

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 |
|---|---|---|---|
| **Energy Research Analyses** | | | |
| ■ Evaluate the quality and relevance of research projects in Science, Fossil Energy, and Energy Efficiency by independent peer reviews and assess additional technical needs in Science, Fossil Energy, and Energy Efficiency (e.g., advanced composite materials). Evaluate critical planning and policy issues of DOE science and technology through reviews by expert groups outside the Department such as the National Academy of Sciences and the JASON group.......................................................................... | 976 | 965 | 973 |

[a] Excludes $23,000 which has been transferred to the SBIR program and $1,000 which has been transferred to the STTR program.

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **SBIR/STTR** | | | |
| ■ In FY 1999, $23,000 and $1,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirement for the continuation of the SBIR and STTR programs. .................... | 0 | 26 | 27 |
| Total, Energy Research Analyses................................................ | 976 | 991 | 1,000 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Energy Research Analyses** | |
| ■ There are no significant funding changes from FY 2000 to FY 2001 for Energy Research Analyses..................................................................... | +8 |
| **SBIR/STTR** | |
| ■ Increase in SBIR/STTR due to increase in operating expenses. .......................... | +1 |
| Total Funding Change, Energy Research Analyses.................................................... | +9 |

# Fusion Energy Sciences

## Program Mission

The Fusion Energy Sciences program is a multi-purpose, scientific research effort, producing valuable scientific knowledge and technological benefits in the near term and providing the science base for a fusion energy option in the long term.

This is a time of important progress and scientific discovery in fusion research. By virtue of previous investments in facilities, sophisticated diagnostics, critical technologies, and modeling capabilities, the Fusion Energy Sciences program is making great progress in understanding the fundamental processes involved in confining fusion fuels, such as the turbulence responsible for loss of particles and energy across magnetic field lines. In addition, the program is exploring innovative approaches to fusion energy, including supporting advances in state-of-the-art enabling technology, in search of an optimized confinement system with an affordable development path.

## Program Goal

During the next 50 years, the world population is expected to increase substantially, and energy usage will likely double. As oil and natural gas reserves are depleted, sustainable new energy sources will be needed. Both the President's Committee of Advisors on Science and Technology and the Secretary of Energy Advisory Board have recognized the potential of fusion energy and have recommended that fusion be a key component of the nation's long-term energy strategy. Accordingly, the long-range goal of the Fusion Energy Sciences program is to:

> *" Advance plasma science, fusion science, and fusion technology, and thereby establish the knowledge base for an economically and environmentally attractive fusion energy source."*

In pursuit of this goal, the program addresses a broad range of science and technology issues, resulting in spinoffs with many near-term applications.

## Program Objectives

The objectives of the Fusion Energy Sciences program have been developed through extensive stakeholder meetings and were endorsed by the Fusion Energy Sciences Advisory Committee and the Secretary of Energy Advisory Board. They are summarized below.

- *Understand the science of plasmas, the fourth state of matter*. Plasmas comprise most of the observable universe, both stellar and interstellar, and have many practical applications. Progress in both plasma science and requisite supporting technology have contributed to the progress in fusion research and, conversely, fusion research has been the dominant driver of plasma science.
- *Identify and explore innovative and cost-effective development paths to fusion energy*. There are several approaches to fusion under investigation in the current program. They range from the advanced tokamak, which is the best understood magnetic confinement concept, and alternative magnetic configurations, to inertial confinement using particle beam or laser drivers.

- *Explore the science and technology of energy producing plasmas, the next frontier in fusion research, as a partner in an international effort*. Fusion research is a worldwide activity, with 80% of the research being conducted outside of the United States. International collaborations are a key strategic element of the U.S. fusion program, allowing us to leverage our funds by gaining access to facilities abroad needed to deal with scientific issues without having to use scarce resources to construct and operate them. Working from similar motivations, many scientists from abroad have participated in experiments on U.S. facilities as well. Interacting with highly qualified scientists from other countries and cultures provides an opportunity to see issues from new and different perspectives, allows solutions to arise from the diversity of the participants, and promotes both cooperation and friendly competition. In short, it provides an exciting and stimulating environment resulting in a synergistic effect that is good for science.

The Fusion Energy Sciences program is composed of three subprograms; Science, Facility Operations, and Enabling R&D. The Science subprogram includes research funds for general plasma science; for experiments on the physics of high temperature plasms in magnetic fields, in both tokamaks and other configurations; for the physics of heavy ion beam accelerators; and for theory and modeling of fusion plasmas. Funds for building, operating, upgrading and decommissioning of major facilities are in the Facility Operations subprogram. The Enabling R&D subprogram includes funds for key fusion technology research and innovations needed to advance fusion science and develop the knowledge base for an attractive fusion energy source. Many of the advances in fusion science that have occurred during the past 30 years have been enabled by technology innovations.

The Fusion Energy Sciences program today is focused primarily on the first two objectives above and the related enabling technology research. Only a small effort on burning plasma physics and related fusion technology, e.g. materials science and engineering research on energy conversion and tritium handling continues.

## Scientific Facilities Utilization

The Fusion Energy Sciences request includes $95,000,000 to operate scientific user facilities. This investment will provide research time for about 500 scientists in universities, federally sponsored laboratories, and industry. It will also leverage both federally and internationally sponsored research, consistent with the Administration's strategy for enhancing the U.S. National science investment. The proposed funding will support operations at the Department's three major fusion energy physics facilities: the Doublet III-D tokamak at General Atomics, the Alcator C-Mod tokamak at the Massachusetts Institute of Technology, and the National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory.

## Performance Measures

The Fusion Energy Sciences program supports the Department's strategic goal of delivering the scientific and technological innovations critical to meeting the Nation's energy challenges. The performance measures of the Fusion Energy Sciences program fall into four areas: (1) excellence of the science, (2) relevance to the DOE mission and national needs, (3) stewardship of research capabilities, and (4) management of human resources. The ways in which the Fusion Energy Sciences program measures performance include merit-based peer review, charges to the Fusion Energy Sciences Advisory Committee (FESAC), and recognition of professional accomplishments of research performers. These measures have been an integral part of the program for many years. Each major research facility has a community based Program Advisory Committee (PAC) that sets priorities for the use of that facility. Proposals for new facilities or upgrades to existing facilities at laboratories receive both scientific and engineering/cost/schedule reviews.

For FY 2001, specific performance measures are:

- Initiate and meet schedules for dismantling, packaging, and offsite shipping of the Tokamak Fusion Test Reactor (TFTR) systems located in the basement of the TFTR building as described in the Decontamination and Decommissioning plan.
- Sustain partnerships that support fusion/plasma sciences, specifically through completion by June 2001 of a new NSF/DOE Partnership in Basic Plasma Science and Engineering to provide continuity after the present agreement ends, and by initiating a new element of the U.S.-Japan collaborative program by the end of FY 2001.
- Evaluate first physics results from the innovative Electric Tokamak (ET) at UCLA, where the long-range goals of this university-scale program (funded at about $2,000,000 per year) are to study fast plasma rotation and associated radial electric fields due to radiofrequency-drive, in order to enhance plasma pressure in sustained, stable plasmas.
- Improve nonlinear magneto-hydrodynamics codes to be capable of computing the effect of realistic resistive walls and plasma rotation on advanced tokamak pressure limits. (These codes may also be capable of modeling the startup of alternate configurations such as the spheromak.)
- Complete by June 2001 the 6 MW power upgrade of the DIII-D microwave system and initiate experiments with it to control and sustain plasma current profiles, with the goal of maintaining improved confinement of plasma energy for longer periods of time.
- Initiate a new phase of the U.S.-Japan collaborative program of research on enabling technologies, materials, and science for an attractive fusion energy source.
- Transfer the waste management and environmental monitoring activities at the Princeton Plasma Physics Laboratory (PPPL) from the Environmental Management program (EM) to the Fusion Energy Sciences program.
- Complete the DOE-Japan Atomic Energy Research Institute (JAERI) collaboration at the Tritium Systems Test Assembly (TSTA) facility at Los Alamos National Laboratory (LANL).

## Significant Accomplishments and Program Shifts

There were six Performance Measures in the FY 1999 Fusion Energy Sciences budget narrative. Each of the six performance measures was either met or exceeded.

- The National Academy of Sciences is reviewing the quality of science in the Fusion Energy Sciences Program. An interim report was issued in August 1999, highlighting the contributions of fusion science to other fields of research. The full study, including strategic recommendations, will be completed in FY 2000.
- All three of the major fusion experiments have been operating as national facilities with research teams composed of participants from throughout the fusion science community. Program advisory committees assure scientific quality and program relevance of the research conducted at each facility.

- The National Spherical Torus Experiment (NSTX) project at the Princeton Plasma Physics Laboratory (PPPL) was completed in FY 1999, achieving its first major operational milestone ahead of schedule. A national research team was organized and the facility began experimental operations in FY 1999.
- Considerable progress has been made in areas such as the macroscopic equilibrium and stability of magnetically confined plasmas and turbulence and transport in tokamak plasmas. Software and hardware were developed that allow remote collaborations on a wide variety of fusion experiments in the United States and abroad.
- The fusion program continued exploring a wide range of confinement concepts other than the tokamak. Including the three new innovative confinement experiments that started operation in FY 1999, there are 13 exploratory level alternate magnetic concept experiments in the United States. In addition, there was increased effort on exploring the physics of a heavy ion accelerator for inertial fusion energy.
- The technology program subelement was restructured in FY 1999, and U.S. participation in the International Thermonuclear Experimental Reactor project was successfully completed.

Other significant accomplishments include:

- A major review of magnetic and inertial fusion energy options was carried out by a task force of the Secretary of Energy Advisory Board in response to congressional requests. The task force report was issued in August 1999. The report's Executive Summary states that "In the light of the promise of fusion and the risks arising from increasing worldwide energy demand and from eventually declining fossil energy supply, it is our view that we should pursue fusion aggressively." The task force also endorsed the revised focus of the magnetic fusion program to understand the science and technology of fusion and concluded that inertial fusion energy warranted continued exploration and development.
- At a two-week long workshop, 350 fusion researchers from the United States and abroad discussed virtually all of the key technical issues associated with fusion science. This workshop provided a very effective forum for enhanced interaction between magnetic fusion and inertial fusion approaches, between science and technology issues, and between basic understanding and energy applications of fusion. The community reaffirmed that the next frontier in magnetic fusion is the science of burning plasmas, and that the tokamak is technically ready for a high-gain burning plasma experiment.
- The Fusion Energy Sciences Advisory Committee (FESAC) led a community assessment of the restructured fusion program and provided a report, with specific recommendations on program priorities and balance, in September 1999.
- Preparation of a strategic plan for Fusion Energy Sciences was initiated in FY 1999. It will be completed early in 2000 incorporating the results of the Secretary of Energy Advisory Board and National Research Council reviews, the recommendations of the Fusion Energy Sciences Advisory Committee, and technical understandings that came from the 1999 Fusion Summer Study.
- DOE and NSF issued a joint announcement for new opportunities for funding in FY 2000 in September 1999 as part of the NSF/DOE Partnership in Basic Plasma Science and Engineering.

- In FY 1999, the general plasma science program was extended to include national laboratories with a solicitation for proposals on applications of plasma science. Proposals, many of which will have evolved from Laboratory Directed R&D programs, will be competitively peer reviewed.
- In late FY 1999 Los Alamos National Laboratory identified future operating cost increases for the Tritium System Test Assembly (TSTA) facility, which was built to study the fusion fuel cycle process. Following DOE and peer review, agreement was reached to complete the highly successful research program by mid-FY 2001. Research will cease then while operation to reduce the inventory of tritium fuel will continue, in preparation for transfer to EM for subsequent decontamination and decommissioning.

**Science Accomplishments**

During the past year, scientific accomplishments covered a wide range of activities ranging from improvements in the detailed understanding of fusion plasma confinement physics to theory and modeling advances that also contribute to fields outside of fusion science. Important examples include the following:

- *Magnetic Reconnection:* The tearing and reconnection of magnetic field lines is of fundamental importance in many areas of plasma physics, including fusion science. Newly developed laboratory experiments at the California Institute of Technology, Swarthmore, and the Princeton Plasma Physics Laboratory have led to significant advances in the understanding of this phenomenon, which is of particular importance in the eruptions of energetic bursts from the surface of the sun, which, in turn affect radio and satellite communications.
- *Understanding the Sharp Edge of the Plasma*: Tokamak plasmas spontaneously generate “transport barriers” that substantially reduce the loss of energy and result in high plasma confinement. When such a barrier forms, the steep pressure gradients that result can give rise to a variety of instabilities. While some instabilities are deleterious, others are benign or even beneficial, as in the regime recently discovered in the Alcator C-Mod tokamak at Massachusetts Institute of Technology, that combines favorable confinement of energetic particles with sufficient particle transport to maintain plasma purity. Installation of high-spatial-resolution diagnostics has enabled measurement, with unprecedented detail, of the plasma profiles in this transport barrier. These measurements are providing critical tests of predictions of stability theory.
- *Relating Plasma Turbulence to the Theory of Avalanches*: Plasma turbulence increases energy transport and thereby limits magnetic confinement. There have been recent attempts to compare plasma transport phenomena with avalanche or “sand pile” transport models. Although plasmas are fluids, Self-Organized Criticality (SOC) models that are used to simulate a wide variety of natural phenomena such as earthquakes, avalanches, etc. describe some nonlinear aspects of plasma turbulence. Measurements of electron temperature and density fluctuations in tokamaks are providing information about the size and frequency of transport events, thus improving comparisons with theoretical avalanche models.
- *Self-Acceleration of the Plasma*: Plasma flows are now known to be critical for improving particle and energy confinement in magnetic confinement configurations. Past experiments have shown that the force exerted on a plasma by injected beams of particles can generate flows through rotation. However, recent observations of rapid rotation in plasmas with radiowave heating rather than beam heating have led to speculation that radiowaves, which do not carry momentum, can also produce rotation. This indicates that it may be possible to use radiofrequency waves to control plasma flow and improve confinement. Focused experiments in Alcator C-Mod now show that even in plasmas

with no additional heating there can be substantial rotation. There is conjecture that this is an intriguing and unexpected effect of turbulent transport.

- *Exploring New Ways to Fuel Fusion Plasmas*: Injecting small pellets of frozen deuterium has long been a technique for fueling fusion plasmas. Usually pellets are launched from the outside, or low magnetic field side, of the tokamaks. But in large, high temperature and high density plasmas this requires extremely high velocity pellets in order to penetrate deep into the plasma core. Recently, pellets injected from the high magnetic field side of the DIII-D tokamak, that is from the center of the "doughnut," penetrated much deeper into the plasma. Analysis of these experiments has helped to uncover key physics missing from earlier pellet penetration codes.
- *New Methods for Starting up Plasmas*: The conventional method for initiating the current in a tokamak—magnetic induction—requires a large transformer winding (or magnet coil) through the center of the tokamak. Non-inductive startup could reduce the size and cost of future fusion devices. By combining edge current drive with the currents driven by radio frequency waves, neutral beam injection, and the bootstrap current generated by plasma pressure itself, calculations have shown that it should be possible to create plasmas in the National Spherical Torus Experiment with currents up to 500,000 amperes. Successful non-inductive startup would permit dispensing with the central magnet, thus simplifying the spherical torus concept enormously.
- *Resolving the Performance Projections for Future Experiments:* Future large-scale fusion devices will require an extrapolation from existing experiments. For several years one of the computer models used for predicting the performance of the International Thermonuclear Experimental Reactor indicated that its performance would be significantly below what empirical extrapolation from present experiments predicts. As a result of concentrated effort by the fusion theorists to understand this difference, it appears that this computer model did not accurately describe certain key physical phenomena. When an improved description of these key physics elements is included in the computer model, there is an increase in the performance projections for ITER, and other large-scale fusion devices, and the expected performance is in the range predicted by a logical empirical extension of present experimental work.
- *MFE Concept Development:* The fusion program is exploring a wide range of confinement concepts other than the tokamak. Three new experiments started operation in FY 1999—the Sustained Spheromak Physics Experiment (SSPX) at the Lawrence Livermore National Laboratory, the flow stabilized pinch experiment (ZAP) at the University of Washington, and the Helically Symmetric Stellarator Experiment (HSX) at the University of Wisconsin. During FY 2000, the Levitated Dipole Experiment at the Massachusetts Institute of Technology will begin operation. This will bring the total number of exploratory level alternate magnetic concept experiments in the United States to 13. This important new investment in the Fusion Energy Sciences program is expected to pay dividends in the form of enhanced understanding of the interaction of plasmas with electric and magnetic fields and lead to significantly better magnetic confinement concepts over the next decade.
- *IFE Concept Development:* There is also increased effort on heavy ion accelerator physics aimed at a driver for inertial fusion. Successful completion of experiments using modular systems would pave the way for the design of an Integrated Research Experiment, a proof-of-principle IFE facility using heavy ions.

### Facility Operations Accomplishments

The Fusion Energy Sciences program operates three major facilities for producing high temperature plasmas hotter than the core of the sun: National Spherical Torus Experimental project (NSTX) at PPPL, DIII-D at General Atomics, and Alcator C-Mod at MIT. These facilities are equipped with extensive diagnostic instruments needed to connect experiments to theory and simulation codes. The scientific understanding developed from these facilities is contributing to the knowledge base for an attractive fusion energy source. Modifications and upgrades at these facilities proceeded on schedule and within cost during FY 1999. The combined average unscheduled downtime for these facilities was about 15% in FY 1999. Research on these facilities is augmented and extended through collaboration with international programs.

- The NSTX project at the Princeton Plasma Physics Laboratory (PPPL) was completed in FY 1999, achieving its first major operational milestone ahead of schedule. A national research team was organized and the facility began experimental operations in FY 1999. In FY 2000, one of the TFTR neutral beams will be installed and research operations will resume in mid-summer.
- Significant modifications to the divertor of the DIII-D facility were initiated in FY 1999 and will be completed in early FY 2000, providing capabilities required for experiments to extend the pulse duration of advanced toroidal operating modes later in the year. These important experiments should demonstrate the conditions necessary for long pulse operations.
- Conceptual design of a plasma heating and current drive system for Alcator C-Mod was completed and favorably reviewed in FY 1999. Design and fabrication will begin in FY 2000. Fabrication will continue in FY 2001. The system will be operational in 2002 and will provide significant enhancement of C-Mod plasma performance and duration.
- Preparations for the decontamination and decommissioning (D&D) of TFTR were initiated at PPPL in FY 1999. During FY 2000, PPPL will complete removal of all systems/components to be retained for future use in the program and will prepare the remaining systems/components for dismantling, removal, and shipment offsite. When D&D is completed, the TFTR test cell will be available for reuse by the Fusion Energy Sciences program.

### Enabling R&D Accomplishments

- At the direction of Congress, U.S. participation in ITER was successfully completed. The Co-center in San Diego was closed and returned to the owner; U.S. secondees to the Joint Central Team returned; and the U.S. responsibilities in component R&D were discharged. Of particular note, the Central Solenoid Model Coil, the largest pulsed superconducting magnet ever built, was completed and shipped to Japan for testing.
- Bilateral and multilateral plasma technology activities on major scientific facilities abroad continued in order to access test conditions not available on domestic facilities.
- The low activation materials research program continued to focus on feasibility issues and to define and extend operating limits of candidate materials systems.
- All Enabling R&D program elements were fully integrated into a Virtual Laboratory for Technology, thus creating a coordinated national program.
- Research on systems with the potential for significantly increasing high heat flux component performance and lifetime was initiated. Such components will be needed for next generation experiments in several of the developing concepts.

- Research on the magnetic, heating, and fueling components that will enable domestic plasma experiments to achieve their full plasma science research objectives continued.

**Awards**

- The MIT Plasma Science and Fusion Center, in collaboration with PNNL, won a **1998 R&D 100 Award** for a device that measures smokestack emissions. The award winning work has its roots in fusion diagnostics and plasma physics.
- Five fusion researchers were elected **Fellows of the American Physical Society in 1999.**
- A University of Wisconsin researcher was awarded **the 1999 APS Award for Excellence in Plasma Physics.** This fusion scientist's work focused on the development and exploitation of a diagnostic to measure fluctuations and their relation to energy transport in hot, fusion-relevant plasmas.
- A University of Michigan faculty member received the **1999 IEEE Plasma Science and Application Award**. This fusion-supported researcher studies the scientific aspects of high power radio frequency tubes.
- The MIT Plasma Science and Fusion Center, developed a microplasmatron fuel converter that was selected as one of the **1999 Discover Award** finalists for technological innovation.
- A **U.S. Patent** was awarded to a LANL researcher and to the Regents of the University of California for a diagnostic that measures small temperature changes in fusion plasmas. The diagnostic is in use in Japan and is of interest to European researchers.

## Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances that are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $96,000 for estimated contractor security clearances in FY 2000 and FY 2001, within this decision unit.

## Workforce Development

The Fusion Energy Sciences program is the Nation's primary sponsor of research in plasma physics and fusion science. The mission of the Fusion Energy Sciences program is to train future researchers not only for fusion research, but also for related areas such as plasma processing, space plasma physics, plasma electronics, and accelerator/beam physics. This program supported 365 graduate students and post doctoral investigators in FY 1999; 49 of these graduate students and post doctoral investigators conducted research at the FES user facilities.

## Funding Profile

(dollars in thousands)

| | FY 1999 Current Appropriation | FY 2000 Original Appropriation | FY 2000 Adjustments | FY 2000 Current Appropriation | FY 2001 Request |
|---|---|---|---|---|---|
| Fusion Energy Sciences | | | | | |
| Science | 111,975 | 141,884 | -3,395 | 138,489 | 136,202 |
| Facility Operations | 61,735 | 72,950 | -1,405 | 71,545 | 77,440 |
| Enabling R&D | 43,538 | 35,166 | -514 | 34,652 | 33,628 |
| Subtotal, Fusion Energy Sciences | 217,248 | 250,000 | -5,314 | 244,686 | 247,270 |
| Use of Prior Year Balances | -1,136[a] | 0 | 0 | 0 | 0 |
| General Reduction | 0 | -945 | +945 | 0 | 0 |
| Contractor Travel | 0 | -1,369 | +1,369 | 0 | 0 |
| Omnibus Rescission | 0 | -3,000 | +3,000 | 0 | 0 |
| Total, Fusion Energy Sciences | 216,112[b] | 244,686 | 0 | 244,686 | 247,270[c] |

**Public Law Authorization:**

Public Law 95-91, “Department of Energy Organization Act”

Public Law 103-62, “Government Performance Results Act of 1993”

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $5,083,000 which has been transferred to the SBIR program and $305,000 which has been transferred to the STTR program.

[c] Includes $3,157,000 for Waste Management activities at Princeton Plasma Physics Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

## Funding By Site

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Albuquerque Operations Office | | | | | |
| Los Alamos National Laboratory | 4,365 | 6,094 | 5,960 | -134 | -2.2% |
| Sandia National Laboratories | 4,120 | 3,338 | 3,232 | -106 | -3.2% |
| Total, Albuquerque Operations Office | 8,485 | 9,432 | 9,192 | -240 | -2.5% |
| Chicago Operations Office | | | | | |
| Argonne National Laboratory | 2,604 | 2,339 | 2,270 | -69 | -2.9% |
| Princeton Plasma Physics Laboratory | 52,129 | 62,970 | 70,219 | +7,249 | +11.5% |
| Chicago Operations Office | 46,304 | 40,768 | 39,770 | -998 | -2.4% |
| Total, Chicago Operations Office | 101,037 | 106,077 | 112,259 | +6,182 | +5.8% |
| Idaho Operations Office | | | | | |
| Idaho National Engineering and Environmental Laboratory | 1,804 | 1,623 | 1,701 | +78 | +4.8% |
| Oakland Operations Office | | | | | |
| Lawrence Berkeley National Laboratory | 4,971 | 7,877 | 7,655 | -222 | -2.8% |
| Lawrence Livermore National Laboratory | 11,696 | 13,063 | 12,716 | -347 | -2.7% |
| Stanford Linear Accelerator Center | 50 | 50 | 0 | -50 | -100.0% |
| Oakland Operations Office | 67,342 | 67,858 | 64,453 | -3,405 | -5.0% |
| Total, Oakland Operations Office | 84,059 | 88,848 | 84,824 | -4,024 | -4.5% |
| Oak Ridge Operations Office | | | | | |
| Oak Ridge Inst. for Science & Education | 471 | 800 | 800 | 0 | 0.0% |
| Oak Ridge National Laboratory | 18,093 | 17,550 | 17,621 | +71 | +0.4% |
| Oak Ridge Operations Office | 89 | 87 | 70 | -17 | -19.5% |
| Total, Oak Ridge Operations Office | 18,653 | 18,437 | 18,491 | +54 | +0.3% |
| Ohio Field Office | 0 | 8 | 0 | -8 | -100.0% |
| Richland Operations Office | | | | | |
| Pacific Northwest National Laboratory | 1,415 | 1,385 | 1,385 | 0 | 0.0% |
| Savannah River Operations | | | | | |
| Savannah River Tech Center | 177 | 0 | 0 | 0 | 0.0% |
| Washington Headquarters | 1,618 | 18,876 | 19,418 | +542 | +2.9% |
| Subtotal, Fusion Energy Sciences | 217,248 | 244,686 | 247,270 | +2,584 | +1.1% |
| Use of Prior Year Balances | -1,136[a] | 0 | 0 | 0 | 0.0% |
| Total, Fusion Energy Sciences | 216,112[b] | 244,686 | 247,270[c] | +2,584 | +1.1% |

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $5,083,000 which has been transferred to the SBIR program and $305,000 which has been transferred to the STTR program.

[c] Includes $3,157,000 for Waste Management activities at Princeton Plasma Physics Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

# Site Description

## Argonne National Laboratory

Argonne National Laboratory (ANL) in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. Argonne's Fusion Energy Sciences program contributes to a variety of fusion enabling R&D program activities in areas of modeling, analysis, and experimental research. Argonne has a lead role internationally in analytical models and experiments for liquid metal cooling in fusion devices, including the ALEX facility, that studies the interaction of flowing liquid metals with magnetic fields, and liquid lithium flow loop that studies corrosion in candidate structural alloy materials. Argonne's capabilities in the engineering design of fusion energy systems has contributed to the design of components such as blankets, tritium systems, and plasma-facing components, as well as to analysis supporting the ARIES studies of fusion power plant concepts. Argonne also contributes to low-activation materials research with its unique capabilities in vanadium alloy testing in fission reactors and post-irradiation examinations.

## Idaho National Engineering and Environmental Laboratory

Idaho National Engineering and Environmental Laboratory (INEEL) is a Multiprogram Laboratory located on 572,000 acres in Idaho Falls, Idaho. Since 1978, INEEL has been the lead laboratory for fusion safety for the Fusion Energy Sciences program. As the lead laboratory, they have helped to develop the fusion safety data base that will demonstrate the environmental and safety characteristics of both nearer term fusion devices and future fusion power plants. They have focused their research on: (1) understanding the behavior of the sources of radioactive and hazardous materials in a fusion machine, (2) understanding the energy sources in a fusion machine that could mobilize these materials, and (3) developing the analytical tools that demonstrate the environmental and safety characteristics of a fusion machine. In FY 2001, fusion efforts at INEEL will be focused on safety research for magnetic and inertial concepts associated with both existing or planned domestic experimental facilities and the domestic research program. In addition, to develop further our domestic safety data base, INEEL will use existing collaborative arrangements to conduct work on existing international facilities.

## Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory (LBNL) is a Multiprogram Laboratory located in Berkeley, California. The Laboratory is on a 200 acre site adjacent to the Berkeley campus of the University of California. One of LBNL's missions is to study and apply the physics of heavy ion beams and to advance related technologies for the U.S. Heavy-Ion Fusion (HIF) program. The HIF program centered at LBNL has the long-range goal of developing inertial fusion energy (IFE) as an economically and environmentally attractive source of electric power.

## Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL) is a Multiprogram Laboratory located on an 821 acre site in Livermore, California. LLNL is host for Defense Programs' National Ignition Facility, which will give the United States the first opportunity in the world to demonstrate inertial fusion ignition and energy gain in the laboratory. This goal will provide the IFE program with crucial results concerning target physics. This fusion energy mission is consistent with the NIF mission statement. Livermore partners with other Laboratories (LBNL, for example, in Heavy Ion Fusion) in fusion energy research. This program also includes collaborations on the DIII-D tokamak at General Atomics, construction of an innovative concept experiment, the Sustained Spheromak Physics Experiment (SSPX) at LLNL, and benchmarking of fusion physics computer models with experiments such as DIII-D. The SSPX started experimental operations in FY 1999. Definitive results on the feasibility of sustaining high temperature spheromak plasmas utilizing external electrode current drive are expected by the end of FY 2000.

## Los Alamos National Laboratory

Los Alamos National Laboratory is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. The FY 2001 budget will support the creation of computer codes for modeling the stability of plasmas, as well as work in diagnostics, innovative fusion plasma confinement concepts such as Magnetized Target Fusion, and the successful completion of the research operations of the Tritium Systems Test Assembly (TSTA) facility.

## Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education (ORISE) is located on a 150 acre site in Oak Ridge, Tennessee. ORISE was established by DOE to undertake national and international programs in education, training, health, and the environment. ORISE and its programs are operated by Oak Ridge Associated Universities (ORAU) through a management and operating contract with DOE. Established in 1946, ORAU is a consortium of 88 colleges and universities. For the Fusion Energy Sciences (FES) program, ORISE acts as an independent and unbiased agent to administer the Fusion Energy Sciences Graduate and Postgraduate Fellowship Programs, in conjunction with FES, the Oak Ridge Operations Office (ORO), participating universities, DOE laboratories, and industries.

## Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL) is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. ORNL develops a broad range of components that are critical for improving the research capability of fusion plasma experiments located at other institutions and that are essential for developing fusion as an environmentally acceptable energy source. The laboratory is a leader in the theory of heating of plasmas by electromagnetic waves, antenna design, and design and modeling of pellet injectors to fuel the plasma and control the density of plasma particles. Research is also done in the area of turbulence and its effect on transport of heat through a plasma. Codes developed at the laboratory are also used to model plasma processing in industry. While some ORNL scientists are located full-time at off-site locations, others carry out their collaborations with short visits to the host institutions, followed by extensive computer communications from ORNL for data analysis and interpretation, and theoretical studies. ORNL leads the advanced materials program, contributes to research on all materials systems of fusion interest, coordinates experimental collaborations for two U.S.-Japan programs, and coordinates materials activities for the Virtual Laboratory for Technology.

## Pacific Northwest National Laboratory

Pacific Northwest National Laboratory (PNNL) is a Multiprogram Laboratory located on 640 acres at the Department's Hanford site in Richland, Washington. The Fusion Energy Sciences program at PNNL is focused on research on materials that can survive in a fusion neutron environment. The available facilities used for this research include mechanical testing and analytical equipment, including state-of-the-art electron microscopes, that are either located in radiation shielded hot cells or have been adapted for use in evaluation of radioactive materials after exposure in fission test reactors. Experienced scientists and engineers at PNNL provide leadership in the evaluation of ceramic matrix composites for fusion applications and support work on vanadium, copper and ferritic steels as part of the U.S. fusion materials team. PNNL also plays a leadership role in a fusion materials collaboration with Japan, with Japanese owned test and analytical equipment located in PNNL facilities and used by both PNNL staff and up to ten Japanese visiting scientists per year.

## Princeton Plasma Physics Laboratory

Princeton Plasma Physics Laboratory (PPPL) is a program-dedicated laboratory (Fusion Energy Sciences) located on 72 acres in Princeton, New Jersey. PPPL is the only U.S. Department of Energy (DOE) laboratory devoted primarily to plasma and fusion science. It hosts experimental facilities used by multi-institutional teams and also sends researchers and specialized equipment to other fusion facilities in the United States and abroad. PPPL is the host for the National Spherical Torus Experiment (NSTX), which is an innovative toroidal confinement device closely related to the tokamak, and is currently working on the conceptual design of another innovative toroidal concept, the compact stellarator. PPPL scientists and engineers have significant involvement in the DIII-D and Alcator C-Mod tokamaks in the U.S. and the large JET (Europe) and JT-60U (Japan) tokamaks abroad. This work is focused on developing the scientific understanding and innovations required for an attractive fusion energy source. PPPL scientists are also involved in several basic plasma science experiments, ranging from magnetic reconnection to plasma processing. PPPL, through its association with Princeton University, provides high quality education in fusion-related sciences, having produced more than 175 Ph.D. graduates since its founding in 1951.

## Sandia National Laboratory

Sandia National Laboratory is a Multiprogram Laboratory, with a total of 3,700 acres, located in Albuquerque, New Mexico, with other sites in Livermore, California, and Tonapah, Nevada. Sandia's Fusion Energy Sciences program plays a lead role in developing plasma-facing components for fusion devices through the study of plasma interactions with materials, the behavior of materials exposed to high heat fluxes, and the interface of plasmas and fusion device first walls. Sandia selects, specifies, and develops materials for components exposed to high heat and particles fluxes and conducts extensive analysis of prototypes to qualify components before their use in fusion devices. Materials samples and prototypes are tested in Sandia's Plasma Materials Test Facility, which uses high-power electron beams to simulate the high heat fluxes expected in fusion environments. Materials and components are exposed to tritium-containing plasmas in the Tritium Plasma Experiment. Tested materials are characterized using Sandia's accelerator facilities for ion beam analysis. Sandia supports a wide variety of domestic and international fusion experiments in areas of tritium inventory removal, materials postmortem analysis, diagnostics development, and component design and testing.

## Stanford Linear Accelerator Center

Stanford Linear Accelerator Center (SLAC) is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California. SLAC is operated for the United States Department of Energy by Stanford University. The main interest in fusion at SLAC is the possibility of adapting the accelerator science and technology from elementary particle physics to the production of fusion power from the implosion of inertial fusion targets driven by beams of high energy, heavy ions. A member of the accelerator research department at SLAC has been involved with the heavy ion fusion program since its inception.

## All Other Sites

The Fusion Energy Sciences program funds research at 54 colleges/universities located in 28 states. Also included are funds for DIII-D and related programs at General Atomics and funding of research grants awaiting distribution pending completion of review results or program office detailed planning.

# Science

## Mission Supporting Goals and Objectives

The goals of the Science subprogram are to advance our understanding of the plasma state and to develop innovative approaches for confining a fusion plasma. These goals are accomplished through a modest program in basic plasma science; active research programs in toroidal concept innovations and non-toroidal concept explorations; strong theory and modeling programs; and the development of improved diagnostics that make possible a rigorous testing of the scientific principles of fusion. A companion objective of the Science subprogram is to broaden the intellectual and institutional base in fundamental plasma physics. Two activities, development activities for junior faculty in plasma physics and an NSF/DOE partnership in plasma physics and engineering, are the major contributors to this objective.

Plasma science is the study of ionized matter, ranging from neon lights to stars, that makes up 99 percent of the observable universe. It includes not only plasma physics but also other physical phenomena in ionized matter, such as atomic, molecular, radiation-transport, excitation, and ionization processes. These phenomena can play significant roles in partially ionized media and in the interaction of plasmas with material walls. Plasma science contributes not only to fusion research, but also to many other fields of national science and technology, including astrophysics, industrial processing, and national security.

Fusion science is focused primarily on describing the fundamental processes in high temperature plasmas (greater than 100,000,000 degrees Celsius) with a confinement parameter (density multiplied by energy confinement time) larger than $10^{20}$ seconds per cubic meter. Nevertheless, fusion science shares many scientific issues with other topical areas of plasma science. These scientific issues include: 1) wave-particle interaction and plasma heating; 2) chaos, turbulence, and transport; 3) sheaths and boundary layers; and 4) stability, magnetic reconnection, and dynamos. Progress in all of these research issues will be required for ultimate success in achieving a practical fusion energy source.

The largest component of the Science subprogram is the tokamak research activity, that focuses on gaining a predictive understanding of the behavior of high temperature, high density plasmas required for fusion energy applications. All of the major scientific issues of fusion science will be studied in an integrated program on the two major U.S. tokamaks, DIII-D at General Atomics and Alcator C-Mod at the Massachusetts Institute of Technology. DIII-D has been a major contributor to the world fusion program over the past decade in the areas of turbulence and transport, boundary layer/divertor physics, and stability. DIII-D has an extensive set of diagnostics and is focused on developing “advanced toroidal” modes of operation using the flexibility of its plasma shaping and computer control systems. Alcator C-Mod uses intense magnetic fields to explore high temperature and high density plasmas in a unique, compact tokamak facility. Alcator C-Mod has been a major contributor to the world fusion program in the areas of wave-particle interaction/plasma heating and boundary layer/divertor physics.

In addition, advanced tokamak research is carried out by U.S. researchers working on international facilities. The Fusion Energy Sciences program has long followed a policy of not duplicating facilities that exist abroad. More recently, the Fusion Energy Sciences Advisory Committee has recommended that the United States increase collaboration on a number of these unique, state-of-the-art foreign facilities. These include the world’s highest performance tokamaks (JET in England and JT-60 in Japan), a new stellarator (the Large Helical Device) in Japan, a superconducting tokamak (Tore Supra) in France, and several smaller devices. In addition, the U.S. is collaborating with South Korea on the design of a long-pulse, superconducting advanced tokamak (KSTAR). These collaborations provide a valuable link with the 80% of the world's fusion research that is conducted outside the U.S.

Research on alternative confinement concepts, both magnetic and inertial, is aimed at identifying approaches that will extend fusion science and that may improve the economical and environmental attractiveness of fusion energy sources. Since this research is exploratory in nature, much of it is carried out on small "concept exploration" experiments; however, a few concepts are sufficiently advanced for medium-size "proof-of-principle" experiments.

Concept exploration experiments typically focus on energy transport and/or plasma stability. These two issues are critical for improved economic attractiveness. Proof-of-principle experiments continue to study these two issues; however, they also begin to focus on wave-plasma interaction, plasma heating, and boundary layer physics.

The first alternate concept proof-of-principle experiment, the new National Spherical Torus Experiment (NSTX) facility at the Princeton Plasma Physics Laboratory (PPPL), began its first full year of operation in FY 2000, with a goal of demonstrating improved plasma stability and confinement in a very compact structure. The Madison Symmetric Torus (MST) at the University of Wisconsin was favorably reviewed by the Fusion Energy Sciences Advisory Committee, and is being upgraded to the proof-of-principle level. A number of concept exploration experiments are in operation or nearly ready to begin operation at various laboratories and universities around the country.

The Inertial Fusion Energy (IFE) activity is exploring an alternate path for fusion energy that would capitalize on the major R&D effort in inertial confinement fusion (ICF) carried out for stockpile stewardship purposes within the Office of Defense Programs. The IFE program depends on the ICF program for experimental research into the physics of target ignition that will be tested in the National Ignition Facility at LLNL. Efforts in IFE focus on understanding the physics of systems or techniques that will be needed to produce a viable inertial fusion energy source. These include the heavy ion beam systems for heating and compressing a target pellet to fusion conditions, the experimental and theoretical scientific basis for modeling target chamber responses, and high-gain target design.

Theory and modeling are essential to progress in fusion and plasma science because they provide the central organizing concepts of the field. They also provide the capability to analyze existing experiments, produce new ideas to improve performance, and provide a scientific assessment of new ideas. An important component of the theory program is the development and use of advanced computational tools to model the complex physical phenomena that govern confinement of high temperature plasmas. Such tools will be necessary to provide a predictive understanding of complex, highly nonlinear fusion systems.

Similarly, the development and improvement of diagnostic tools for analyzing plasma behavior continues to provide new insights into fusion plasmas and enables the detailed comparison of fusion theory and experiments.

## Performance Measures

- Sustain partnerships that support fusion/plasma sciences, specifically through completion by June 2001 of a new NSF/DOE Partnership in Basic Plasma Science and Engineering to provide continuity after the present agreement ends, and by initiating a new element of the U.S.-Japan collaborative program by the end of FY 2001.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Tokamak Experimental Research | 45,824 | 47,561 | 44,456 | -3,105 | -6.5% |
| Alternative Concept Experimental Research | 37,263 | 53,243 | 50,299 | -2,944 | -5.5% |
| Theory | 22,666 | 24,536 | 27,536 | +3,000 | +12.2% |
| General Plasma Science | 6,222 | 7,964 | 8,450 | +486 | +6.1% |
| SBIR/STTR | 0[a] | 5,185 | 5,461 | +276 | +5.3% |
| Total, Science | 111,975 | 138,489 | 136,202 | -2,287 | -1.7% |

## Detailed Program Justification

(dollars in thousands)

| FY 1999 | FY 2000 | FY 2001 |
|---|---|---|

### Tokamak Experimental Research

- **DIII-D Research:** The DIII-D facility at General Atomics is directed towards the investigation of the physics of Advanced Tokamak concepts. Since the early 1990s, the experimental results from DIII-D and other tokamaks worldwide have shown that the use of detailed plasma control techniques such as selective heating, fueling, and current drive impacts the performance of tokamak plasmas considerably. The underlying physical processes that affect tokamak performance are complex and require extensive diagnostics and theoretical support to understand them. DIII-D, the largest U.S. fusion experiment, is extensively equipped with diagnostics to investigate these challenging scientific issues with a large group of collaborators from the many U.S. and international fusion groups. In FY 2001, initial results will be obtained on Advanced Tokamak integration (optimizing transport, power exhaust, profile control simultaneously) using the upgraded current drive and

[a] Excludes $4,020,000 which has been transferred to the SBIR program and $241,000 which has been transferred to the STTR program.

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| power exhaust systems and a wide range of diagnostics. These results will be analyzed using the latest theory and modeling to evaluate the future scientific path for Advanced Tokamaks.. | 21,931 | 23,025 | 21,617 |
| ■ **Alcator C-Mod Research:** The Alcator C-Mod facility, by virtue of its very high magnetic field, is particularly well suited to operate in plasma regimes which are relevant to future much larger fusion tokamaks as well as compact, high field ignition tokamaks. The approach to ignition and sustained burn of a plasma is an important scientific issue for fusion. In FY 2001, Alcator C-Mod will address issues relevant to the confinement and heating of ignition tokamaks. It will also examine the physics of the plasma edge, power and particle exhaust from the plasma, mechanisms of self-generation of flows in the plasma, and improved confinement modes with currents driven by radio waves. New diagnostics made possible by the commissioning of a new diagnostic neutral beam in FY 2000 will be available in FY 2001. These new diagnostics will allow for improved comparisons between theory and experimental results. | 7,775 | 7,870 | 7,367 |
| ■ **International Collaborations and Education:** International collaboration at the level of $4,329,000 provides the opportunity for U.S. scientists to work with their colleagues on unique foreign tokamaks (JET, Tore Supra, TEXTOR, and ASDEX-UG in Europe, JT-60U in Japan, and K-STAR in Korea). These collaborations produce complementary and comparative data to those obtained on the U.S. tokamaks to further the scientific understanding of fusion physics and enhance the pace of fusion energy development. In FY 2001, the collaboration with these programs will focus on the physics of Advanced Tokamaks, Burning Plasmas, and long pulse physics issues. The remaining $4,118,000 is required primarily for graduate and postgraduate fellowships in fusion science and technology, summer internships for undergraduates, general science literacy programs with teachers and students, support for historically black colleges and universities, and similar broad outreach efforts related to fusion science and technology. | 8,495 | 9,181 | 8,447 |
| ■ **Experimental Plasma Research (Tokamaks):** Several unique, innovative tokamak experiments are supported at leading universities. These focus on various topics, including advanced toroidal operating modes and plasma stability and control. The Electric Tokamak at UCLA will begin research | | | |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| operation. This program also develops unique diagnostic probes that provide an understanding of the plasma behavior in fusion research devices, supplying the necessary information for analysis codes and theoretical interpretation. Some key areas of diagnostic research include: 1) techniques to measure temperature and density profiles and fluctuations in these profiles to provide a better understanding of transport and 2) methods to measure the production and confinement of alpha particles to prepare for future burning plasma experiments. The requested funding level in FY 2001 supports the core diagnostic development research, as well as the work begun as a result of an FY 1999 competitive initiative to develop new diagnostic techniques.......................... | 7,623 | 7,485 | 7,025 |
| Total, Tokamak Experimental Research............................................ | 45,824 | 47,561 | 44,456 |

**Alternative Concept Experimental Research**

| | | | |
|---|---|---|---|
| ■ **NSTX Research:** The NSTX at PPPL will complete the first year of scientific research in FY 2000. The research program, that is carried out by a national team made up of PPPL and other laboratory and university researchers, includes plasma formation, methods of controlled startup, plasma heating by radiofrequency waves and diagnostic implementation. Research in FY 2001 will pursue noninductive assisted startup at high currents and test stability properties of the spherical torus configuration....................................................... | 9,906 | 12,874 | 12,250 |

- **Experimental Plasma Research (Alternates):** This budget category includes most of the experimental research on plasma confinement configurations outside of the three large fusion facilities described elsewhere. It consists of twelve smaller experiments (concept exploration level [CE]), one intermediate level experiment (proof-of-principle [PoP]) and one large study program that is focused on obtaining a design for another Proof-of-Principle experiment – a compact stellarator.

  The majority of the research is directed toward toroidal configuration with nested magnetic surfaces. For configurations with a large toroidal magnetic field, the research is focused on stellarators with special symmetry properties. The Helically Symmetric Torus, now operating at the University of Wisconsin, is the world's first stellarator designed using these symmetry principles. There is also another large effort underway, that is studying the design of a

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| Proof of Principle level stellarator with symmetry properties similar to those of the tokamak but without externally driven plasma current. Also, in this category are two very low aspect ratio concept exploration level spherical tokamak experiments (Helicity Injection Tokamak at the University of Washington and the Pegasus Experiment at the University of Wisconsin), which will study the physics of toruses with only a very small hole in the middle. Such configurations stretch conventional stability theory into unexplored regimes.<br>Research on configurations where the toroidal field is less than the poloidal field concentrates on magnetic turbulence and reconnection. This program includes Madison Symmetric Torus (University of Wisconsin), a concept exploration level experiment at LLNL, and a small experiment at California Institute of Technology designed to study basic physics of the reconnection process itself.<br>Research on toroidal systems with closed magnetic field lines concentrates on systems where the lines close upon themselves the short way around (poloidally) the torus. The field reversed configuration (FRC) experiment at the University of Washington, the world's most advanced experiment of this type, focuses on stability issues. The ion ring experiment at Cornell University seeks gross stabilization of the FRC through the use of large ion orbits. The levitated dipole experiment (LDX) at MIT studies a variant where the confining poloidal magnetic fields are generated by a superconducting magnetic ring located within the plasma itself. Dipole confinement is of great importance in many solar and astrophysical systems.<br>The magnetized target fusion program (funded by the FES program) at LANL and the Air Force Research Laboratory will study the possibility that a FRC can be compressed to multi-keV temperatures using fast liner technology developed by the defense programs. ........................................ | 18,980 | 25,088 | 23,665 |

- **Inertial Fusion Energy Experiments:** The inertial fusion energy program has research components that encompass many of the scientific and technical elements that form the basis of an inertial fusion energy system. Heavy ion accelerators continue to be the leading candidate driver. Understanding the physics of the heavy ion beam, that is a non-neutral plasma, is one of the outstanding scientific issues. Considerable progress has been made on developing a

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| model for the accelerator, with the goal of providing a predictive "end-to-end" capability. The elements of this model must be compared to experimental results, and this effort will continue. Technical elements of the program include the continuing development of experimental systems to study beam formation, acceleration and focussing. The design of fusion energy targets will continue, benefiting from presently available high energy density physics data. Physics experiments to be carried out on Defense Programs' National Ignition Facility will ultimately provide validation of target design. Emphasis will be maintained on critical scientific research topics that, even with reduced efforts, will allow modest progress to be made in developing the scientific and technical foundations of inertial fusion energy. ........................ | 8,377 | 15,281 | 14,384 |
| Total, Alternative Concept Experimental Research.......................... | 37,263 | 53,243 | 50,299 |

**Theory**

- The theoretical problems in plasma science are formidable. The goal of the theory and computation program is to achieve a quantitative understanding of the behavior of fusion plasmas. Considerable progress has been made in areas such as the macroscopic equilibrium and stability of magnetically confined plasmas and turbulence and transport in tokamak plasmas. The theory and computing program is a broad-based program with researchers located at national laboratories, universities, and industry. There is an increased program emphasis on advanced computing, including the development of improved modeling codes and a code library for use by all fusion researchers. Work in tokamak theory includes not only efforts to support analysis of experiments, but also includes the development of many new theories and tools that model plasma behavior in advanced tokamaks. These tools will later be extended to innovative confinement geometries. The majority of the work in toroidal theory is aimed at developing a predictive understanding of advanced tokamak operating modes. In alternate concept theory, the emphasis will be on understanding the fundamental processes determining equilibrium, stability, and confinement in each concept. Generic theory supports the development of basic plasma theory and atomic physics theory that is applicable not only to fusion research, but also to basic plasma science. The objective of the advanced computing activity is to improve computational simulation

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| and modeling capabilities in order to obtain a quantitative understanding of plasma behavior in fusion experiments. This will ensure optimum use of a set of innovative national experiments and fruitful collaboration on major international facilities. | | | |
| In FY 2001, funds will be used to develop improved models of equilibrium and stability and turbulence and energy transport in toroidal magnetic confinement systems and to improve the fidelity of heavy ion accelerator models. The Fusion Energy Sciences program will select the research projects on advanced simulation and modeling of fusion plasma systems using a competitive peer review process........... | 22,666 | 24,536 | 27,536 |
| **General Plasma Science** | | | |
| ■ The plasma science program focuses on basic plasma science and, engineering research. This research is carried out primarily by the University community, but DOE laboratories are expected to make contributions as well. Advances in basic plasma physics contribute to the foundation of the Fusion Energy Sciences program as well as other important areas of science and technology. This program provides a strong contribution to the education of plasma physicists. The Plasma Science Junior Faculty Development Program will continue at FY 2000 levels. Collaborative efforts such as the NSF/DOE plasma science and engineering program will continue. In FY 2000 opportunities were made available to DOE laboratory plasma scientists to compete for funding for basic and applied plasma physics research. Laboratory scientists form an important component of the general plasma science community. They also operate unique user facilities such as the Magnetic Reconnection Experiment (MRX) at PPPL. In FY 2001, laboratory activities will be maintained at a constant level. The program will also continue to collect and distribute atomic physics data for fusion. .................................. | 6,222 | 7,964 | 8,450 |
| **SBIR/STTR** | | | |
| ■ In FY 1999, $4,020,000 and $241,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirement for the continuation of the SBIR and STTR programs. ......................... | 0 | 5,185 | 5,461 |
| Total, Science........................................................................... | 111,975 | 138,489 | 136,202 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Tokamak Experimental Research** | |
| ■ The level of participation by the collaborators and on site staff in physics research and data analysis will decrease on DIII-D. | -1,408 |
| ■ Participation of offsite collaborators and development of diagnostics will decrease on Alcator C-Mod | -503 |
| ■ There is a decrease in diagnostic development within Tokamak Experimental Plasma Research. | -460 |
| ■ This decrease primarily results from decreased effort in international collaboration on medium-size tokamaks. | -734 |
| Total, Tokamak Experimental Research | -3,105 |
| **Alternative Concept Experimental Research** | |
| ■ The decrease in support for NSTX research will impact data collection and analysis, and funds for enhancement of existing research collaborations and preparation of advanced diagnostics | -624 |
| ■ Funding for alternate concepts experiments is reduced. | -1,423 |
| ■ The IFE program is reduced to fund other fusion program priorities. Programmatic emphasis will be placed on scientific areas which will enable progress to be made in the development of the scientific and technical foundations of inertial fusion energy. | -897 |
| Total, Alternative Concept Experimental Research | -2,944 |
| **Theory** | |
| ■ The theory program will include increased effort on advanced computational simulation and modeling of complex fusion systems. | +3,000 |
| **Basic Plasma Science** | |
| ■ Increased funding in basic plasma science will be directed to the support of user facilities in basic plasma science | +486 |
| **SBIR/STTR** | |
| ■ Support for SBIR/STTR is mandated at 2.65 percent. These grants will support plasma and fusion science. | +276 |
| Total Funding Change, Science | -2,287 |

# Facility Operations

## Mission Supporting Goals and Objectives

This activity provides for the operation and maintenance of major fusion research facilities; namely, DIII-D at GA, Alcator C-Mod at MIT, and NSTX at PPPL. These user facilities enable U.S. scientists from universities, industry, and laboratories, as well as visiting foreign scientists, to conduct world-class research on the behavior of fusion plasmas. The facilities consist of magnetic plasma confinement devices, plasma heating and current drive systems, diagnostics and instrumentation, experimental areas, computing and computer networking facilities, and other auxiliary systems. This activity includes the cost of operating and maintenance personnel, electric power (about 3% of the total operating cost at a research facility), expendable supplies, replacement parts, subsystem modifications and enhancements, and inventories. In the case of PPPL, funding is provided for continuing the decontamination and decommissioning of the Tokamak Fusion Test Reactor, which was shut down in FY 1997; ongoing caretaking for the tritium systems and radioactive elements is also required during this process. In addition, in FY 2001, the Fusion Energy Sciences program will take over waste management activities from the Environmental Management (EM) program for the PPPL site. General plant projects (GPP) funding for PPPL supports minor facility renovations and other capital alterations and additions for buildings and utility systems. Capital equipment funding for upgrading the research capability of DIII-D and C-Mod is also included to further enhance the facilities.

The principal objective of the Facility Operations subprogram is to maximize the quantity and quality of data collected at the major fusion energy science facilities while complying with all applicable safety and environmental requirements and cultivating an environment of operational excellence.

The following table summarizes the scheduled weeks of operations for DIII-D, C-Mod, and NSTX.

## Performance Measures

- Complete by June 2001 the 6 MW power upgrade of the DIII-D microwave system and initiate experiments with it to control and sustain plasma current profiles, with the goal of maintaining improved confinement of plasma energy for longer periods of time.
- Initiate and meet schedules for dismantling, packaging, and offsite shipping of the Tokamak Fusion Test Reactor (TFTR) systems.

## Facility Utilization

(Weeks of Operations)

| | FY 1999 | FY 2000 | FY 2001 |
|---|---|---|---|
| DIII-D | 14 | 14 | 17 |
| Alcator C-Mod | 12 | 18 | 14 |
| NSTX | 6 | 14 | 17 |

## Funding Schedule

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| TFTR | 3,949 | 13,422 | 19,600 | +6,178 | +46.0% |
| DIII-D | 29,065 | 31,098 | 29,255 | -1,843 | -5.9% |
| Alcator C-Mod | 10,223 | 10,657 | 10,042 | -615 | -5.8% |
| NSTX | 17,022 | 15,406 | 14,469 | -937 | -6.1% |
| General Plant Projects/Other | 1,476 | 962 | 917 | -45 | -4.7% |
| Waste Management | 0 | 0 | 3,157 | +3,157 | +100.0% |
| Total, Facility Operations | 61,735 | 71,545 | 77,440 | +5,895 | +8.2% |

## Detailed Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **TFTR** | | | |
| ■ Continue the decontamination and decommissioning (D&D) of TFTR ($16,000,000). This activity will provide for the removal and disposal of the tokamak and remaining radioactive components from the test cell and the basement. In addition, during the D&D, $3,600,000 is necessary to maintain and keep the facility safe. | 3,949 | 13,422 | 19,600 |
| **DIII-D** | | | |
| ■ Provide support for operation, maintenance, and improvement of the DIII-D facility and its auxiliary systems, such as the Electron Cyclotron Heating (ECH) systems, developed by the Enabling R&D subprogram. In FY 2001, these funds support 17 weeks of plasma operation during which time fusion research experiments will be conducted. The fabrication and installation of the 6 megawatt, 110 GHz ECH system will be completed in FY 2001. | 29,065 | 31,098 | 29,255 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Alcator C-Mod** | | | |
| ■ Provide support for operation, maintenance and minor machine improvements. In FY 2001, these funds support 14 weeks of plasma operation during which time fusion research experiments will be conducted. Design and construction of the Lower Hybrid Current Drive System will continue. This is a Major Item of Equipment with a TEC of $4,200,000 that will be initiated in FY 2000............................ | 10,223 | 10,657 | 10,042 |
| **NSTX** | | | |
| ■ Provide continuation of operational activity on the NSTX experiment and installation of planned diagnostic upgrades. These funds support 17 weeks of plasma operation during which time fusion research experiments will be conducted...... | 8,122 | 12,906 | 14,469 |
| ■ **NSTX Project:** Project completed in FY 1999 and facility begins operations...................................................................... | 5,450 | 0 | 0 |
| ■ **NSTX Neutral Beam:** The NSTX neutral beam modification will be completed in FY 2000 and will be integrated into the NSTX research facility for use in FY 2001 research programs. .................................................... | 3,450 | 2,500 | 0 |
| Total, NSTX ....................................................................... | 17,022 | 15,406 | 14,469 |
| **General Plant Projects/Other** | | | |
| ■ These funds provide primarily for general infrastructure repairs and upgrades for the PPPL site..................................... | 1,476 | 962 | 917 |
| **Waste Management** | | | |
| ■ These funds provide the support necessary to handle all waste management activities at the PPPL site .......................... | 0 | 0 | 3,157 |
| Total, Facility Operations ................................................................ | 61,735 | 71,545 | 77,440 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **TFTR** | |
| ■ Decommissioning of TFTR proceeds on schedule for completion in 2002 | +6,178 |
| **DIII-D** | |
| ■ Operating time of DIII-D is increased by 3 weeks and modest refurbishments are carried out | +3,050 |
| ■ The heating system upgrade modification to DIII-D is completed in FY 2001 | -4,893 |
| Total, DIII-D | -1,843 |
| **Alcator C-Mod** | |
| ■ Modifications to the device's heating system will be delayed and operating time decreased by 4 weeks. | -615 |
| **NSTX** | |
| ■ Support for operating the heating systems on NSTX is increased and operating time is increased by 3 weeks. | +1,563 |
| ■ Decrease due to completion of NSTX neutral beam heating system fabrication project in FY 2000 | -2,500 |
| Total, NSTX | -937 |
| **GPP/Other** | |
| ■ Completion of ongoing repairs will continue at essentially the FY 2000 level | -45 |
| **Waste Management** | |
| ■ Responsibility for waste management activities at the PPPL site has been transferred to the Fusion Energy Sciences program from the Environmental Management program in FY 2001. These funds are being transferred to the program in order to provide an incentive for the laboratory to minimize the amount of waste they produce. | +3,157 |
| Total Funding Change, Facility Operations | +5,895 |

# Enabling R&D

## Mission Supporting Goals and Objectives

For sustained progress toward ultimate research goals, science-oriented programs that push the frontiers of human knowledge, such as fusion, require intellectual resources, experimental facilities with state-of-the-art technological capabilities, and continuing technology innovations. The Enabling R&D subprogram provides for such progress in both magnetic and inertial fusion energy research. This subprogram is divided into two elements: Engineering Research and Materials Research.

The Engineering Research element underwent a major restructuring in FY 1999 when the U.S. stopped participating in the International Thermonuclear Experimental Reactor project. The scope of activities has been substantially broadened to address more fully the diversity of domestic interests in enabling R&D for both magnetic and inertial fusion energy systems. These activities now focus on critical technology needs for enabling U.S. plasma experiments to achieve their full performance capability. Also, international technology collaborations allow the U.S. to access plasma experimental conditions not available domestically. These activities also include investigation of the scientific foundations of innovative technology concepts for future experiments. Another activity is advanced design of the most scientifically challenging systems for next step fusion research facilities, i.e. facilities that may be needed in the immediate future. Also included are analysis and studies of critical scientific and technological issues, the results of which will provide guidance for optimizing future experimental approaches and for understanding the implications of fusion research on power plant applications. Major FY 1999/2000 accomplishments include: completed fabrication of the world's largest pulsed superconducting magnet coil, and shipped it for testing in a Japanese facility; completed fabrication and testing of both a prototype actively cooled, high surface heat flux divertor system and a robotic vacuum vessel welding system; and demonstrated world record performance levels for a plasma heating microwave power tube.

The Materials Research element continues to focus its scientific research on low-activation materials, that have high performance capability and can withstand long-term exposure to the energetic particles and electromagnetic radiation expected from energy-producing plasmas. Efforts continued on mapping of irradiation effects on candidate low-activation alloys, that will be used to set priorities for future research. Recommendations provided in an FY 1998 FESAC review were followed by strengthening the modeling and theory component of materials research, by greater integration with other fusion program elements, and by expansion to include conditions and materials of interest to both magnetic and inertial fusion energy systems.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Engineering Research | 36,698 | 26,578 | 25,943 | -635 | -2.4% |
| Materials Research | 6,840 | 7,167 | 6,804 | -363 | -5.1% |
| SBIR/STTR | 0[a] | 907 | 881 | -26 | -2.9% |
| Total, Enabling R&D | 43,538 | 34,652 | 33,628 | -1,024 | -3.0% |

## Detailed Justification

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 |
|---|---|---|---|
| **Engineering Research** | | | |
| ■ Plasma Technology efforts will be focused on critical needs of domestic plasma experiments and on the scientific foundations of innovative technology concepts for use in both future magnetic and inertial fusion experiments and attractive fusion energy sources. Nearer-term experiment support efforts will be oriented toward plasma facing components and plasma heating and fueling technologies. Longer-term efforts will be oriented toward superconducting magnet research to reduce magnet costs and improve their reliability | 19,475 | 12,085 | 11,664 |
| ■ Fusion Technology will be focused on technology innovations and model improvements needed to resolve critical issues faced by inertial fusion concepts and possibly magnetic concepts as well. These issues include the vacuum chamber as well as tritium and safety research that are critical to the safety and environmental attractiveness of all fusion systems. In the tritium area, TSTA will complete its mission in FY 2001 and research will cease, while tritium inventory reduction will continue in preparation for decommissioning. Management of all of the diverse collection of fusion technologies will be accomplished through a Virtual Laboratory for Technology whereby community-based coordination and communication of plans, progress, and results will be accomplished through the use of modern information technology. | 8,096 | 9,222 | 9,373 |

[a] Excludes $1,063,000 which has been transferred to the SBIR program and $64,000 which has been transferred to the STTR program.

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| ■ Advanced Design and Analysis will be modestly reduced and redirected to include design of the most critical systems for fusion research facilities that may be needed in the near future, and analysis of cost-effective research pathways. | 9,127 | 5,271 | 4,906 |
| Total, Engineering Research | 36,698 | 26,578 | 25,943 |
| **Materials Research** | | | |
| ■ Materials research remains a key element in developing a safe, reliable, and environmentally attractive fusion energy system. Scientific understanding and the development, research, and testing of vanadium alloys, silicon carbide composite materials, and advanced ferritic steels for structural service in the high power zones for fusion energy sources will continue. Priorities for this work, including innovative approaches to evaluating materials and improved modeling of materials behavior, are guided by the results of a Fusion Energy Sciences Advisory Committee review conducted during 1998 and include materials and conditions relevant to inertial fusion systems as well as magnetic systems | 6,840 | 7,167 | 6,804 |
| **SBIR/STTR** | | | |
| ■ In FY 1999, $1,063,000 and $64,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirement for the continuation of the SBIR and STTR programs. | 0 | 907 | 881 |
| Total, Enabling R&D | 43,538 | 34,652 | 33,628 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Engineering Research** | |
| ■ Plasma Technology is decreased in the areas of magnetics and plasma facing components | -421 |
| ■ Fusion Technology is increased to include additional efforts on inertial fusion tasks | +151 |
| ■ Advanced Design and Analysis effort is reduced and will be focused on selected critical topics. | -365 |
| Total Engineering Research | -635 |
| **Materials Research** | |
| ■ Research on modeling of materials will be reduced. | -363 |
| **SBIR/STTR** | |
| ■ Requirements reduced as Enabling R&D is decreased. | -26 |
| Total Funding Change, Enabling R&D | -1,024 |

# Capital Operating Expenses & Construction Summary

## Capital Operating Expenses

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| General Plant Projects | 1,165 | 862 | 822 | -40 | -4.6% |
| Capital Equipment | 17,475 | 13,946 | 7,115 | -6,831 | -49.0% |
| Total, Capital Operating Expenses | 18,640 | 14,808 | 7,937 | -6,871 | -46.4% |

## Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

| | Total Estimated Cost (TEC) | Prior Year Approp- riations | FY 1999 | FY 2000 | FY 2001 | Accept- ance Date |
|---|---|---|---|---|---|---|
| DIII-D Upgrade | 27,367 | 17,437 | 4,023 | 5,400 | 507 | FY 2001 |
| NSTX | 21,100 | 15,650 | 5,450 | 0 | 0 | FY 1999 |
| NSTX – Neutral Beam | 5,950 | 0 | 3,450 | 2,500 | 0 | FY 2000 |
| Alcator C-Mod LH Modification | 4,200 | 0 | 0 | 1,120 | 1,864 | FY 2002 |
| Total, Major Items of Equipment | | 33,087 | 12,923 | 9,020 | 2,371 | |

# Science Program Direction

## Program Mission

This program provides the Federal staffing and associated funding required to provide overall direction of activities carried out under the following programs in the Office of Science (SC): High Energy Physics, Nuclear Physics, Biological and Environmental Research, Basic Energy Sciences, Fusion Energy Sciences, Computational and Technology Research, Multiprogram Energy Laboratories-Facilities Support, and Energy Research Analyses. This funding also provides the necessary support to the Director of SC to carry out SC's responsibilities under the Department of Energy (DOE) Organization Act (P.L. 95-91) and as mandated by the Secretary. These responsibilities include providing advice on the status and priorities of the Department's overall research and development programs and on the management of the Department's multipurpose laboratories; developing research and development plans and strategies; supporting university and science education; and ensuring the institutional health and overall site integration at three multi-program field offices. This program also provides program-specific staffing resources at the Chicago, Oakland, and Oak Ridge Operations Offices directly involved in executing SC programs.

The Program Direction subprogram has been divided into four categories: Salaries and Benefits, Travel, Support Services, and Other Related Expenses, the latter including the Working Capital Fund. "Support Services" refers to support services contracts that provide necessary support functions to the Federal staff, such as technical support, computer systems development, travel processing, and mailroom activities. "Other Related Expenses" refers to other administrative costs of maintaining Federal staff, such as building and facility costs and utilities in the field, information technology expenses, and training. The Working Capital Fund includes centrally provided goods and services at Headquarters, such as supplies, rent and utilities.

The Science Education subprogram focuses primarily on undergraduate research experiences at the national laboratories. Science Education also supports the Albert Einstein Distinguished Educator Fellowships, the National Science Bowl, and the DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges.

The Energy Research Undergraduate Laboratory Fellowships, formerly known as the Laboratory Cooperative Program, are designed to provide educational training and research experiences at DOE laboratories for highly motivated undergraduate students. These opportunities complement academic programs and introduce students to the unique intellectual and physical resources present at the DOE laboratories. Appointments are available during the spring, summer, and fall terms.

In 1991, as a national initiative, the National Science Bowl was developed to encourage high school students from across the Nation to excel in math and science and to pursue careers in those fields. It provides students and their teachers a forum to receive national recognition for their talent and hard work. DOE is committed to math and science education to help provide a technically trained and diverse workforce for the Nation. The National Science Bowl is a highly publicized academic competition among teams of high school students who answer questions on scientific topics in astronomy, biology, chemistry, mathematics, physics, earth, computer and general science. Since its inception, more than 60,000 high school students have participated in regional tournaments leading up to the national finals.

The Albert Einstein Distinguished Educator Fellowship Act of 1994 was signed into law in November 1994. The law gives DOE responsibility for administering the program of distinguished educator fellowships for elementary and secondary school mathematics and science teachers. This program supports outstanding teachers of science and mathematics, who provide insights, extensive knowledge and practical experience to the Legislative and Executive branches.

The DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges is a collaboration between DOE (and five of its multiprogram laboratories) and the American Association of Community Colleges. It is designed to provide educational training and research experiences at five DOE national laboratories for highly motivated community college students. Each laboratory will offer a ten-week summer experience for selected students from a regional consortium of community colleges partnering with DOE and that laboratory.

The Field Operations subprogram enables three Operations Offices to provide the managerial, business, fiduciary, contractual, and technical foundation necessary to support the programmatic missions performed in support of science and technology, national security, energy research, and environmental management. These resources provide for the administrative staff, technical experts, and operational requirements that support the direct program activities at Chicago, Oak Ridge, and Oakland, and the laboratories and facilities under their purview.

## Program Goal

- Fund the staff and related expenses needed to provide overall management direction of SC's basic and fundamental scientific research programs funded in the Science appropriation.
- Enable the Director of SC to serve as the Department's science advisor for formulation and implementation of basic and fundamental research policy.
- Sustain U.S. leadership in science, technology, and engineering by leveraging DOE resources in partnership with laboratories and facilities that contribute to the development of a diverse scientific and technical workforce for the 21st century.
- Provide management and administrative services, at reduced costs through consolidation and re-engineered processes, that enable the Chicago, Oakland and Oak Ridge Operations Offices to continue environmental cleanups; reduce surplus weapons' inventory; support the national laboratories and research facilities; institute environmental, safety and health initiatives.
- Maintain communications with stakeholders.
- Create public and private partnerships.
- Take advantage of reindustrialization opportunities.

## Program Objectives

### Program Direction

- To develop, direct and administer a complex and broadly diversified program of mission-oriented basic and applied research and development designed to support new and improved energy, environmental and health technologies.
- To manage the design, construction, and operation of forefront scientific research facilities for use by the Nation's scientific community, including the Spallation Neutron Source Project.
- To conduct independent technical assessments, peer reviews and evaluations of research proposals, programs and projects.
- To enhance international collaboration and leverage the U.S. investment in research and development.
- To review, analyze and, where appropriate, champion the recommendations of SC's Federally chartered advisory committees, including the Fusion Energy Sciences Advisory Committee, High Energy Physics Advisory Panel, Nuclear Science Advisory Committee, Basic Energy Sciences Advisory Committee, Biological and Environmental Research Advisory Committee, and Advanced Scientific Computing Advisory Committee.

### Science Education

- To provide opportunities and effective mechanisms for students and faculty to participate at the Department's laboratories in hands-on research experiences, related to SC's research programs, with a focus on undergraduates.

### Field Operations

- To provide the day-to-day managerial, business, fiduciary, contractual, and technical foundation necessary to support programmatic missions in the areas of science and technology, national security, energy research, and environmental management.
- To improve the efficiency of operations through development and implementation of integrated business management systems.
- To maintain the field infrastructure in an environment that is safe and hazard free.
- To improve communications with customers, stakeholders, and the public.

## Performance Measures

### Program Direction

- Responsiveness to national science policy and major science initiatives.

- Improvement in environment, safety, and health compliance and reduction of waste generation and environmental emissions.
- Make provisions for new and/or enhanced research facilities and equipment within scope and budget and on schedule.
- Continue improvements in the utilization of staffing, travel, and support contractor funds.
- Continue to improve levels of facility operating time.
- Expand international collaborative efforts.
- Cost share and leverage program resources with other agencies on a one-to-one basis to multiply the program's impact.

### Science Education

- Increase the flow of underrepresented students up to 50 percent into science and math programs/careers.

### Field Operations

- Award management and operating contract for the Y-12 Plant.
- Realize cost avoidance of at least 10 percent by consolidating the development of information systems and network architecture, and acquisition of information technology.
- Automate budget transmissions between the contractor/laboratories, the Operations Offices, and Headquarters.

## Significant Accomplishments and Program Shifts

### Program Direction

- SC Headquarters continues to achieve technical excellence in its programs despite managing one of the largest, most diversified and most complex basic research portfolios in the Federal Government with a relatively small Federal and contractor support staff.
- Concluded the international agreement for U.S. participation in the Large Hadron Collider project. Signatories included the Secretary of Energy and the Director of the National Science Foundation. Execution of the project is ongoing.
- Continue operation of the William R. Wiley Environmental Molecular Sciences Laboratory at Pacific Northwest National Laboratory.
- At Fermilab, completed construction of the C-Zero Experimental Hall within scope and budget, and on schedule (FY 1999 completion); and completed the Main Injector within scope and budget, and on schedule (FY 1999 initial operation).
- Completed the B-factory and its detector at the Stanford Linear Accelerator Center within scope and

budget, and on schedule (FY 1999 initial operation).

- Enhance the scientific capabilities for experiments at the Thomas Jefferson National Accelerator Facility (TJNAF) to provide new opportunities for researchers. Three TJNAF experimental halls will be fully operational.
- Carry out experiments at the Radioactive Ion Beam facility at Oak Ridge National Laboratory.
- Transfer of management responsibility from Environmental Management to Science for newly generated wastes at Ames, Argonne National Laboratory/East, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory, and Princeton Plasma Physics Laboratory.
- Manage the Joint Genome Institute and the Atmospheric Radiation Measurement sites using the national laboratories as an integrated system.
- Strengthen integrated safety and security management and infrastructure management at the national laboratories.
- Operate the state-of-the-art National Energy Research Scientific Computing and Energy Science Network for the benefit of SC and DOE.
- Plan and manage a complex, scientific R&D program to establish the knowledge base needed for an attractive fusion energy source.
- Continue to refine framework of appropriate international arrangements needed to carry out SC programs in a most cost-effective manner.
- Continue enhancement of neutron science capability at the Los Alamos Neutron Science Center and the High Flux Isotope Reactor at Oak Ridge.
- Continue design and construction of the Neutrinos at the Main Injector project.
- Accomplished the U.S. withdrawal from the International Thermonuclear Experimental Reactor program consistent with congressional direction and appropriated funds while preserving effective working relationships with affected U.S. institutions.
- Completed the National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory within scope and budget (FY 1999), achieving first plasma milestone ahead of schedule.
- Completed the assessment of the quality of fusion science requested by the Office of Science and Technology Policy and carried out by the National Research Council of the National Academy of Sciences.
- The Office of Fusion Energy Sciences will respond to recommendations from the Secretary of Energy Advisory Board review of DOE fusion energy programs and the Fusion Energy Sciences Advisory Committee report on opportunities and requirements of fusion energy.
- Began construction of the Spallation Neutron Source Project Office at Oak Ridge National Laboratory in FY 2000.

### Science Education

- The Energy Research Undergraduate Laboratory Fellowship Program has implemented an innovative, interactive Internet system to receive and process hundreds of student applications for summer and semester research appointments at 11 participating DOE laboratories. The automated system is virtually paperless and provides an excellent example of how the Internet can be used to streamline the operation of the Department's research participation programs.
- Through special recruitment efforts, the Energy Research Undergraduate Laboratory Fellowship Program has attracted a diverse group of students using the electronic application. Nearly 20 percent of those submitting applications were from underrepresented ethnic groups. About 40 percent of the applications were from females, and more than 25 percent were from low-income families. More than 600 summer 1999 appointments were made through the new application process.
- Five additional regional competitions were held in conjunction with DOE's National Science Bowl. More than 9,000 high school students participated in the 53 regional science bowl tournaments.
- The Albert Einstein Distinguished Educator Fellowship awards to pre-college science, math and technology teachers will place four individuals in Congressional offices and DOE, as directed by legislation.
- In FY 1999, SC piloted its DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges. In the summer of 1999, 125 community college students attended an eight-week scientific research experience at five DOE multipurpose laboratories. Additionally, seven community college faculty members were also selected to work in these DOE laboratories. More than 80 percent of the participating students came from underrepresented groups in math, science, engineering, and technology and many were "non-traditional" students.

### Field Operations

- The contract with Stanford University was renewed. The incumbent of this contract is responsible for managing the Stanford Linear Accelerator Center along with the Stanford Synchrotron Research Laboratory. This new performance-based contract is valued at $10,000,000 through FY 2003.
- As a result of project management activities at Chicago, the first shipment of Tritium Producing Burnable Absorber Rods to Tennessee Valley Authority (TVA) reactors will be completed on the commercial light water reactor production of tritium project.
- Negotiations have been completed with TVA to provide reactors to irradiate Tritium Producing Burnable Absorber Rods to guarantee the U.S. a supply of tritium for weapons use.
- The Human Genome Production Sequencing Facility in Walnut Creek, California, was dedicated and is operational. This facility will house a team of scientists from Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory that are working on the

Human Genome Sequencing Project.

- A multi-year contract with Boeing North American Company, valued at $148,500,000, was signed to complete the restoration and remediation of DOE's former Energy Technology Engineering Center in Southern California.
- The contract for the Oak Ridge National Laboratory was awarded to University of Tennessee - Battelle, Limited Liability Company.

## Funding Profile

(dollars in thousands)

| | FY 1999 Current Appropriation | FY 2000 Original Appropriation | FY 2000 Adjustments | FY 2000 Current Appropriation | FY 2001 Request |
|---|---|---|---|---|---|
| Science Program Direction | | | | | |
| Program Direction | 44,953 | 47,860 | 0 | 47,860 | 51,438[a] |
| Science Education | 4,500 | 4,500 | 0 | 4,500 | 6,500 |
| Field Operations | 0[b] | 78,748 | 0 | 78,748 | 83,307 |
| Total, Science Program Direction | 49,453 | 131,108 | 0 | 131,108 | 141,245 |
| Staffing (FTEs) | | | | | |
| Headquarters (FTEs) | 264 | 274 | 0 | 274 | 284 |
| Field (FTEs) | 49 | 51 | 0 | 51 | 62 |
| Field Operations (FTEs) | 0 | 767 | 0 | 767 | 732 |
| Total, FTEs | 313 | 1,092 | 0 | 1,092 | 1,078 |

**Public Law Authorization:**

Public Law 95-91, "Department of Energy Organization Act"

Public Law 103-62, "Government Performance Results Act of 1993"

[a] Includes $631,000 in FY 2001 for Waste Management activities at Chicago and Oakland Operations Offices that was previously budgeted in FY 1999 and FY 2000 by the Environmental Management program.

[b] Appropriated in Energy Supply Research and Development and managed by the Office of Field Integration in FY 1999.

## Funding by Site

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Chicago Operations Office | | | | | |
| Argonne National Laboratory | 797 | 200 | 900 | +700 | +350.0% |
| Brookhaven National Laboratory | 398 | 250 | 600 | +350 | +140.0% |
| Princeton Plasma Physics Laboratory | 0 | 0 | 250 | +250 | +100.0% |
| Chicago Operations Office | 3,948 | 29,226 | 30,577 | +1,351 | +4.6% |
| Total, Chicago Operations Office | 5,143 | 29,676 | 32,327 | +2,651 | +8.9% |
| Oakland Operations Office | | | | | |
| Lawrence Berkeley National Laboratory | 309 | 225 | 500 | +275 | +122.2% |
| Stanford Linear Accelerator Center | 15 | 0 | 150 | +150 | +100.0% |
| Oakland Operations Office | 957 | 21,399 | 23,761 | +2,362 | +11.0% |
| Total, Oakland Operations Office | 1,281 | 21,624 | 24,411 | +2,787 | +12.9% |
| Oak Ridge Operations Office | | | | | |
| Oak Ridge Institute For Science & Education | 1,495 | 725 | 1,700 | +975 | +134.5% |
| Oak Ridge National Laboratory | 439 | 320 | 800 | +480 | +150.0% |
| Thomas Jefferson National Accelerator Facility | 0 | 0 | 150 | +150 | +100.0% |
| Oak Ridge Operations Office | 792 | 34,525 | 36,625 | +2,100 | +6.1% |
| Total, Oak Ridge Operations Office | 2,726 | 35,570 | 39,275 | +3,705 | +10.4% |
| Richland Operations Office | | | | | |
| Pacific Northwest National Laboratory | 572 | 275 | 750 | +475 | +172.7% |
| Washington Headquarters | 39,731 | 43,963 | 44,482 | +519 | +1.2% |
| Total, Science Program Direction | 49,453 | 131,108 | 141,245[a] | +10,137 | +7.7% |

[a] Includes $631,000 in FY 2001 for Waste Management activities at Chicago and Oakland Operations Offices that was previously budgeted in FY 1999 and FY 2000 by the Environmental Management program.

## Site Description

### Argonne National Laboratory

Argonne National Laboratory (ANL) in Argonne, Illinois, is a multi-program laboratory located on a 1,700-acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

### Brookhaven National Laboratory

Brookhaven National Laboratory is a multi-program laboratory located on a 5,200-acre site in Upton, New York. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

### Chicago Operations Office

Chicago is responsible for the integrated management of its five performance-based contractor laboratory sites--Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Princeton Plasma Physics Laboratory, and Ames Laboratory; and two government-owned and government-operated federal laboratories--Environmental Measurements Laboratory and New Brunswick Laboratory. Chicago has oversight responsibility for more than 10,000 contractor employees located at various site offices across the Nation. This responsibility includes ensuring the security and environmental safety of the taxpayer's investment--approximately 16,000 acres of land with a physical plant worth of about $5.8 billion. Chicago is often noted as a leader in both intellectual property matters and managing more than 2,000 active procurement instruments. Several departmental elements rely on these patent services and the expertise within this Center of Excellence for Acquisitions and Assistance.

### Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is a multi-program laboratory located in Berkeley, California. The laboratory is on a 200-acre site adjacent to the Berkeley campus of the University of California. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

## Oakland Operations Office

Oakland is responsible for supporting the national securities and science, physics and biomedical research, and high energy physics activities which contribute to the California economy. These activities are conducted mostly at the following major laboratories for which Oakland has oversight responsibility: Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, and Stanford Linear Accelerator Center. Oakland administers more than 1,600 contracts, grants and assistance awards valued at about $28 billion. Oakland Operations Office manages $1.2 billion in major industrial contracts with Westinghouse, General Electric, and General Atomics and Combustion Engineering. As a Grants Center of Excellence, Oakland administers all grants west of the Mississippi.

## Oak Ridge National Laboratory

Oak Ridge National Laboratory is a multi-program laboratory located on a 24,000-acre site in Oak Ridge, Tennessee. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

## Oak Ridge Operations Office

Oak Ridge has oversight responsibility for the Oak Ridge National Laboratory (ORNL), the East Tennessee Technology Park (ETTP), Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, Y-12 Plant, and the government owned and operated Oak Ridge Institute of Science and Education. Oak Ridge has oversight responsibility for more than 15,000 contractor employees located at these sites, as well as responsibility for over 43,000 acres of land and approximately 46,000,000 square feet of facility space, valued at over $12 billion. ORNL has responsibility for the Spallation Neutron Source (construction began in FY 2000). The Y-12 Plant has recently resumed weapons production operations, and the ETTP is responsible for utilizing DOE assets by recycling metals, the sale of precious metals, and the disposition of uranium. Other major initiatives at Oak Ridge include reducing environmental risk; reducing the Y-12 weapons footprint; re-industrializing the ETTP and some parts of the Y-12 Plant for commercial use; the revitalization of the scientific infrastructure; and creating public and private partnerships for regional economic development. Oak Ridge is also recognized as one of the Department’s three Financial Centers of Excellence.

## Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education (ORISE) is located on a 150-acre site in Oak Ridge, Tennessee. ORISE conducts research into modeling radiation dosages for novel clinical, diagnostic, and therapeutic procedures. In addition, ORISE coordinates several research fellowship programs and the peer review of all Basic Energy Research funded science.

## Pacific Northwest National Laboratory

Pacific Northwest National Laboratory is a multi-program laboratory located on 640 acres at the Department's Hanford site in Richland, Washington. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

## Princeton Plasma Physics Laboratory

Princeton Plasma Physics Laboratory is a program-dedicated laboratory (Fusion Energy Sciences) located on 72 acres in Princeton, New Jersey. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

## Stanford Linear Accelerator Center

Stanford Linear Accelerator Center is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

## Thomas Jefferson National Accelerator Facility

Thomas Jefferson National Accelerator Facility is a program-dedicated laboratory (Nuclear Physics) located on 273 acres in Newport News, Virginia. Educational activities supported at the laboratory are directed towards providing hands-on research experiences for undergraduate student and science teacher participants on state-of-the-art equipment while engaging them on important issues at the forefront of scientific inquiry.

# Program Direction

## Mission Supporting Goals and Objectives

Program Direction provides the Federal staffing resources and associated costs required for overall direction and execution of SC program and advisory responsibilities. Program Direction supports staff in the High Energy Physics, Nuclear Physics, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, Computational and Technology Research, Multiprogram Energy Laboratories-Facilities Support, and Energy Research Analyses programs, including management and technical support staff. The staff includes scientific and technical personnel as well as program support personnel in the areas of budget and finance; general administration; grants and contracts; information resource management; policy review and coordination; infrastructure management; construction management; safeguards and security; and environment, safety and health. This program also provides program-specific staffing resources at the Chicago, Oakland, and Oak Ridge Operations Offices directly involved in executing SC programs.

Program Direction also includes resources to cover the costs of centrally provided goods and services procured through the Working Capital Fund at Headquarters, such as supplies, rent, telecommunications, desktop infrastructure, etc.

## Funding Schedule

| | (dollars in thousands, whole FTEs) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Chicago Operations Office | | | | | |
| Salaries and Benefits | 3,054 | 3,345 | 3,800 | +455 | +13.6% |
| Travel | 187 | 190 | 212 | +22 | +11.6% |
| Support Services | 198 | 160 | 160 | 0 | 0.0% |
| Other Related Expenses | 124 | 166 | 180 | +14 | +8.4% |
| Total, Chicago Operations Office | 3,563 | 3,861 | 4,352 | +491 | +12.7% |
| Full-Time Equivalents | 32 | 32 | 37 | +5 | +15.6% |
| | | | | | |
| Oakland Operations Office | | | | | |
| Salaries and Benefits | 867 | 889 | 988 | +99 | +11.1% |
| Travel | 51 | 51 | 47 | -4 | -7.8% |
| Support Services | 0 | 0 | 0 | 0 | 0.0% |
| Other Related Expenses | 39 | 39 | 55 | +16 | +41.0% |
| Total, Oakland Operations Office | 957 | 979 | 1,090 | +111 | +11.3% |
| Full-Time Equivalents | 10 | 10 | 11 | +1 | +10.0% |

| (dollars in thousands, whole FTEs) | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Oak Ridge Operations Office | | | | | |
| Salaries and Benefits | 634 | 833 | 1,498 | +665 | +79.8% |
| Travel | 40 | 70 | 82 | +12 | +17.1% |
| Support Services | 0 | 52 | 56 | +4 | +7.7% |
| Other Related Expenses | 68 | 117 | 178 | +61 | +52.1% |
| Total, Oak Ridge Operations Office | 742 | 1,072 | 1,814 | +742 | +69.2% |
| Full-Time Equivalents | 7 | 9 | 14 | +5 | +55.6% |
| Headquarters | | | | | |
| Salaries and Benefits | 28,409 | 30,180 | 33,349 | +3,169 | +10.5% |
| Travel | 1,240 | 1,420 | 1,359 | -61 | -4.3% |
| Support Services | 5,146 | 5,120 | 4,887 | -233 | -4.6% |
| Other Related Expenses | 4,896 | 5,228 | 4,587 | -641 | -12.3% |
| Total, Headquarters | 39,691 | 41,948 | 44,182 | +2,234 | +5.3% |
| Full-Time Equivalents | 264 | 274 | 284 | +10 | +3.6% |
| Total Science | | | | | |
| Salaries and Benefits | 32,964 | 35,247 | 39,635 | +4,388 | +12.4% |
| Travel | 1,518 | 1,731 | 1,700 | -31 | -1.8% |
| Support Services | 5,344 | 5,332 | 5,103 | -229 | -4.3% |
| Other Related Expenses | 5,127 | 5,550 | 5,000 | -550 | -9.9% |
| Total, Science Program Direction | 44,953 | 47,860 | 51,438 | +3,578 | +7.5% |
| Total, Full -Time Equivalents | 313 | 325 | 346 | +21 | +6.5% |

## Detailed Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Salaries and Benefits** | | | |
| SC monitors and evaluates over 3,500 grants and contracts at more than 225 institutions, including universities, industry and other government agencies and programs at 13 national and single-purpose laboratories. In FY 2001, SC will support the Re-engineering Waste Management transfers at management and operating contractor facilities administered by the Chicago and Oakland Operations Offices and the management structure of the Spallation Neutron Source Project.<br><br>Also in FY 2001, SC will support the Scientific and Technical Workforce Retention and Recruitment effort. The Department of Energy has conducted detailed workforce analyses that have identified current and projected staffing shortfalls, especially among the scientific and technical disciplines. During 1999, DOE conducted a systematic analysis of critical staffing needs within the context of current and projected Research & Development (R&D) program missions. The Department will focus on building and sustaining a talented and diverse workforce of R&D Technical Managers. This will include innovative recruitment strategies, retention incentives, comprehensive training and development programs for new and current employees, and succession planning. The FY 2001 program direction request for SC includes $1,186,000 in salaries and benefits for this effort. This will enable the recruitment of experienced scientists and related support staff (10 full-time equivalents) in areas of emerging interest to the Department's science mission. Funds will also be used to motivate and retain highly skilled, top-performing technical managers with, for example, retention allowances and performance awards.......... | 32,964 | 35,247 | 39,635 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Travel** | | | |
| Travel includes all costs of transportation of persons, subsistence of travelers, and incidental travel expenses in accordance with Federal travel regulations. Travel also includes transportation costs for new hires and Federal transferees in support of Scientific and Technical Workforce Retention and Recruitment efforts. Alternatives to travel such as teleconferencing will continue to be utilized when possible. | 1,518 | 1,731 | 1,700 |
| **Support Services** | | | |
| Provides the minimum level of support services needed for mailroom operations; travel management; environment, safety and health support; safeguards and security; computer systems development; and hardware and software installation, configuration, and maintenance activities. As a Lead Program Secretarial Office, the capability to develop/implement integrated business management systems and the related information technology infrastructure is required in order to strengthen collaborative efforts between Headquarters and field components. | 5,344 | 5,332 | 5,103 |
| **Other Related Expenses** | | | |
| Provides funds to enhance the technical and professional capability of the Federal staff, acquire computer hardware and software necessary to accomplish corporate systems development and networking upgrades, and provide $3,506,000 for Working Capital Fund assessments. Funding in support of the Scientific and Technical Workforce Retention and Recruitment effort in areas crucial for effective job performance is also included. .................. | 5,127 | 5,550 | 5,000 |
| Total, Program Direction............................................................ | 44,953 | 47,860 | 51,438 |

## Explanation of Funding Changes From FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Salaries and Benefits** | |
| ▪ The increase includes cost of living, locality pay, within grades, promotions, and awards; 5 FTEs at Oak Ridge Operations Office to complete the management structure of the Spallation Neutron Source Project Office; 5 FTEs at Chicago and 1 FTE at Oakland Operations Offices to support the Waste Management transfers; and 10 FTEs in support of the Scientific and Technical Workforce Retention and Recruitment effort. | +4,388 |
| **Travel** | |
| ▪ The decrease reflects a continuing effort to reduce travel costs............................................ | -31 |
| **Support Services** | |
| ▪ The decrease represents efficiencies achieved in information technology............................ | -229 |
| **Other Related Expenses** | |
| ▪ The decrease represents a reduction (-$712,000) in maintenance costs associated with information management activities, offset by an increase in the Working Capital Fund (+$162,000)........................................................................................................ | -550 |
| Total Funding Change, Program Direction.................................................................... | +3,578 |

## Support Services

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Technical Support Services | | | | | |
| Economic and Environmental Analysis | 1,488 | 1,325 | 1,325 | 0 | 0.0% |
| Test and Evaluation Studies | 160 | 100 | 100 | 0 | 0.0% |
| Total, Technical Support Services | 1,648 | 1,425 | 1,425 | 0 | 0.0% |
| Management Support Services | | | | | |
| Management Studies | 207 | 110 | 110 | 0 | 0.0% |
| Training and Education | 63 | 40 | 40 | 0 | 0.0% |
| ADP Support | 2,376 | 2,847 | 2,618 | -229 | -8.0% |
| Administrative Support | 1,050 | 910 | 910 | 0 | 0.0% |
| Total, Management Support Services | 3,696 | 3,907 | 3,678 | -229 | -5.9% |
| Total, Support Services | 5,344 | 5,332 | 5,103 | -229 | -4.3% |

## Other Related Expenses

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Training | 68 | 74 | 74 | 0 | 0.0% |
| Working Capital Fund | 3,000 | 3,344 | 3,506 | +162 | +4.8% |
| Printing and Reproduction | 33 | 11 | 0 | -11 | -100.0% |
| Rental Space | 26 | 0 | 0 | 0 | 0.0% |
| Software Procurement/Maintenance Activities/Capital Acquisitions | 2,000 | 2,115 | 1,420 | -695 | -32.9% |
| Other | 0 | 6 | 0 | -6 | -100.0% |
| Total, Other Related Expenses | 5,127 | 5,550 | 5,000 | -550 | -9.9% |

# Science Education

## Mission Supporting Goals and Objectives

For over 50 years, the Department of Energy and its predecessor agencies have supported science and engineering education programs involving university faculty as well as pre-college teachers and students. The Department has provided support for university students, pre-college teachers and college faculty through hands-on research experiences at the Department's national laboratories and research facilities.

The involvement of DOE's national laboratories in faculty/student research is perhaps the most distinguishing feature of the agency's participation over the years in science and engineering education. No other Federal agency has the extensive network of research laboratories and facilities as DOE with its unique physical and human resources. These laboratories and facilities have been the key to the Department's contribution over time to the Nation's science and engineering education goals.

As we approach the new century, the Nation continues to face important challenges related to recruiting and retaining students who have historically been under-represented (e.g., women, disabled persons, African Americans, Hispanic Americans and Native Americans) in science and engineering fields. Guided by recent reports such as the National Research Council on Undergraduate Education Achievement Trends in Science and Engineering, SC will continue to design an undergraduate research fellowship program that couples academic study with extensive hands-on research experiences in a variety of DOE national laboratory settings. This program is intended to enhance the likelihood that under-represented students will successfully complete their undergraduate studies and move on to graduate school. Historically, over two-thirds of undergraduates who have participated in DOE programs such as this have gone on to graduate school in disciplines directly relevant to the DOE science and technology missions.

## Funding Schedule

(dollars in thousands)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Energy Research Undergraduate Laboratory Fellowships | 3,215 | 3,160 | 3,700 | +540 | +17.1% |
| National Science Bowl Program | 400 | 400 | 400 | 0 | 0.0% |
| Albert Einstein Distinguished Educator Fellowship Program | 385 | 440 | 400 | -40 | -9.1% |
| DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges | 500 | 500 | 2,000 | +1,500 | +300.0% |
| Total, Science Education | 4,500 | 4,500 | 6,500 | +2,000 | +44.4% |

## Detailed Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Energy Research Undergraduate Laboratory Fellowships** | | | |
| The Energy Research Undergraduate Laboratory Fellowship Program is a key component of Science Education. The program enables students to focus their research interests on solving current scientific problems and prepare for meeting the challenge of DOE's future energy science mission requirements. This program provides undergraduates real hands-on experiences at the national laboratories and facilities. The program will ensure a steady flow of students with technical expertise into the Nation's pipeline of workers in both academia and industry........................................................................ | 3,215 | 3,160 | 3,700 |
| **National Science Bowl Program** | | | |
| SC will manage and support the National Science Bowl for high school students from across the country. Since its inception, more than 60,000 high school students have participated in this event. The National Science Bowl is a highly publicized academic competition among teams of high school students who answer questions on scientific topics in astronomy, biology, chemistry, mathematics, physics, earth, computer, and general science. In 1991, DOE developed the National Science Bowl to encourage high school students from across the Nation to excel in math and science and to pursue careers in those fields. It provides the students and teachers a forum to receive national recognition for their talent and hard work. DOE plans to invest $400,000 in the National Science Bowl to manage both regional and national competitions.......................................... | 400 | 400 | 400 |
| **Albert Einstein Distinguished Educator Fellowship Program** | | | |
| The Albert Einstein Fellowship Awards for pre-college science, math and technology teachers continues to be a strong pillar of the program for bringing real classroom experiences to our education programs and outreach activities. This Congressional initiative, established by the Albert Einstein Distinguished Educator Fellowship Act of | | | |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| 1994, has enabled the Department to maintain an enriching relationship with the National Triangle Coalition that serves the Federal Government as the clearinghouse for selecting the teachers. DOE plans to invest $400,000 in the Einstein Fellowship Awards that will allow us to place teachers at the Department and in the U.S. Congress. .................................. | 385 | 440 | 400 |
| **DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges** The DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges is a collaborative effort between DOE and five of its multiprogram laboratories with the American Association of Community Colleges and specified member institutions. This program is designed to address shortages, particularly at the technician and paraprofessional levels, in the rapidly expanding areas of biotechnology, environmental science, and computing, that will help develop the human resources needed to continue building the Nation's capacity in these critical areas for the next century. The Institute provides a 10-week research fellowship for highly qualified community college students at a DOE national laboratory. Students are mentored by world-renowned scientists, learn scientific inquiry and methodology to solve complex scientific problems, are introduced to and learn to use the latest scientific instruments, and learn about career options in the science and technology enterprise. To be eligible, students must: (1) be enrolled in at least six hours of coursework at the time of application; (2) be interested in a career in the fields of biotechnology, environmental science, or computing; (3) have completed at least 12 hours of community college credits that count toward a degree with at least six hours in science mathematics, engineering, or technology courses; (4) have a minimum undergraduate grade point average of 3.25 on a 4.0 scale; (5) be a citizen of the United States or a Permanent Resident Alien; and (6) be at least 18 years of age by June 1 of the year of the appointment. Students apply through an on-line application process................................................................ | 500 | 500 | 2,000 |
| | 4,500 | 4,500 | 6,500 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| Total, Science Education......................................................... | | | |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Energy Research Undergraduate Laboratory Fellowship Program** | |
| ▪ Increase the number of students for fall and spring research appointments | +540 |
| **Albert Einstein Fellowship** | |
| ▪ One fellowship recipient was given an additional time extension in FY 2000. | -40 |
| **DOE Institute of Biotechnology, Environmental Science, and Computing for Community Colleges** | |
| ▪ Expanding the Community College program from a pilot to a full competitive program. | +1,500 |
| Total Funding Changes, Science Education | +2,000 |

# Field Operations

## Mission Supporting Goals and Objectives

The Field Operations subprogram pays the salaries and benefits of the Federal personnel located at the Chicago, Oakland, and Oak Ridge Operations Offices. The staff is responsible for managing the daily business, administrative and technical services that support Science and other DOE program-specific scientific and technical work within the field and laboratory structure. The following administrative and technical services are provided by this core matrix staff: financial stewardship, personnel management, contract and procurement acquisition, labor relations, legal counsel, public and congressional liaison, intellectual property and patent management, environmental compliance, safety and health management, infrastructure operations maintenance, information systems development and support, and reindustrialization.

In addition, this subprogram provides funding for the fixed requirements associated with rent, utilities, and telecommunications. Other requirements such as information systems support, administrative support, mail services, printing and reproduction, travel, certification training, vehicle acquisition and maintenance, equipment, classified/unclassified data handling, records management, health care services, guard services, and facility and ground maintenance are also included. These infrastructure requirements are relatively fixed. The offices are also responsible for supplying office space and materials for the Office of Inspector General located at each site. With the budget reductions over the immediate past years, these areas are already funded at the minimum level necessary to support the Department's critical missions in the field.

Other operational requirements funded include occasional contractor support to perform ecological surveys, cost validations, and environmental assessments; ensure compliance with Defense Nuclear Safety Board safety initiatives; abide by site preservation laws and regulations; and perform procurement contract closeout activities. Departmental and programmatic initiatives as well as regional and congressional constituents influence these requirements.

## Funding Schedule

(dollars in thousands, whole FTEs)

| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
|---|---|---|---|---|---|
| Chicago Operations Office | | | | | |
| Salaries and Benefits | 0 | 20,021 | 19,958 | -63 | -0.3% |
| Travel | 0 | 350 | 396 | +46 | +13.1% |
| Support Services | 0 | 1,500 | 1,829 | +329 | +21.9% |
| Other Related Expenses | 0 | 3,054 | 3,642 | +588 | +19.3% |
| Total, Chicago Operations Office | 0 | 24,925 | 25,825 | +900 | +3.6% |
| Full-Time Equivalents | 0 | 253 | 236 | -17 | -6.7% |
| Oakland Operations Office | | | | | |
| Salaries and Benefits | 0 | 14,994 | 15,370 | +376 | +2.5% |
| Travel | 0 | 250 | 259 | +9 | +3.6% |
| Support Services | 0 | 2,092 | 2,831 | +739 | +35.3% |
| Other Related Expenses | 0 | 3,084 | 4,211 | +1,127 | +36.5% |
| Total, Oakland Operations Office | 0 | 20,420 | 22,671 | +2,251 | +11.0% |
| Full-Time Equivalents | 0 | 178 | 171 | -7 | -3.9% |
| Oak Ridge Operations Office | | | | | |
| Salaries and Benefits | 0 | 26,435 | 27,518 | +1,083 | +4.1% |
| Travel | 0 | 400 | 345 | -55 | -13.8% |
| Support Services | 0 | 3,026 | 2,745 | -281 | -9.3% |
| Other Related Expenses | 0 | 3,542 | 4,203 | +661 | +18.7% |
| Total, Oak Ridge Operations Office | 0 | 33,403 | 34,811 | +1,408 | +4.2% |
| Full-Time Equivalents | 0 | 336 | 325 | -11 | -3.3% |
| Total Field Operations | | | | | |
| Salaries and Benefits | 0 | 61,450 | 62,846 | +1,396 | +2.3% |
| Travel | 0 | 1,000 | 1,000 | 0 | 0.0% |
| Support Services | 0 | 6,618 | 7,405 | +787 | +11.9% |
| Other Related Expenses | 0 | 9,680 | 12,056 | +2,376 | +24.5% |
| Total, Field Operations | 0[a] | 78,748 | 83,307 | +4,559 | +5.8% |
| Full-Time Equivalents | 0 | 767 | 732 | -35 | -4.6% |

[a] Appropriated in Energy Supply Research and Development and managed by the Office of Field Integration in FY 1999.

## Detail Program Justification

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Salaries and Benefits** | | | |
| ▪ Funds the management and administrative staff that complement the multiple program-specific efforts performed within the field and laboratory structure under the auspices of three multi-program Operations Offices (Chicago, Oakland, and Oak Ridge). The FY 2001 budget request supports 732 full-time equivalents. From FY 2000 to the FY 2001 request, the full-time equivalents have been reduced by 4.6 percent. With such a reduction, in FY 2001, the staff will be devoted to re-engineering business processes, developing process improvements, and investing in information technology. ................. | 0 | 61,450 | 62,846 |
| **Travel** | | | |
| ▪ Enables field staff to participate on task teams, work various issues, conduct compliance reviews, and perform contractor oversight to ensure implementation of DOE orders and regulatory requirements at the facilities under their purview. Also provides for attendance at conferences and training classes, and permanent change of station relocation, etc. ................................ | 0 | 1,000 | 1,000 |
| **Support Services** | | | |
| ▪ Provides centralized information management systems and administrative support at each office. For FY 2001, the field will need to make information technology infrastructure investments that will build on the integrated business management systems and support re-engineered processes and process improvements. These requirements are in addition to the routine computer programming, local area network connectivity, computer desktop maintenance, communications centers, and audio/TeleVideo support. A variety of other support services are also fundamental requirements at each office, which include mail distribution, travel management, contract closeout, remote site office support, copy and distribution centers, trash removal, and facility and grounds maintenance, etc........................................... | 0 | 6,618 | 7,405 |

| | (dollars in thousands) | | |
|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 |
| **Other Related Expenses**<br>Provides funds necessary for day-to-day requirements associated with operating a viable office. Within this category, $8,000,000 funds the fixed requirements associated with rent, utilities, and telecommunications. More than half of the $8,000,000 is associated with office space occupied within Federal buildings and the rent paid to the General Services Administration. Eliminating the amount of space occupied has moderately reduced the rent expense. The remaining $4,056,000 supports information technology infrastructure investments ($1,400,000) and other day-to-day expenses ($2,656,000), including postage, printing and reproduction, computer hardware and software, copier leases, and in most cases the site-wide health care service and vehicle fleet maintenance. Employee training and development and the supplies and furnishings used by the Federal staff are also included | 0 | 9,680 | 12,056 |
| Total, Field Operations | 0 | 78,748 | 83,307 |

## Explanation of Funding Changes from FY 2000 to FY 2001

| | FY 2001 vs. FY 2000 ($000) |
|---|---|
| **Salaries and Benefits** | |
| ▪ This increase is the net effect of changes in the staffing level from FY 2000 to FY 2001. The funding change represents a decrease in related costs associated with early retirements needed in FY 2000 to make significant reductions in the Federal staffing level. In addition, the savings, related to the 4.6 percent reduction in full- time equivalents from FY 2000 to FY 2001, support a decrease in the funding request. These decreases are offset by an allowance for general pay and locality raises, promotions, and within grades in FY 2001 | +1,396 |
| **Travel** | |
| ▪ Travel remains the same as the prior year as this level supports increasing oversight responsibilities | 0 |
| **Support Services** | |
| ▪ The increase will support obtaining expertise that will facilitate process improvements, develop state-of-the-art automation tools, and build on existing integrated business management systems among three field offices. Under the Department's new management structure, SC and the three Operations Offices are collaborating in a corporate, integrated approach to business systems, utilizing strategic information planning and information architecture | +787 |
| **Other Related Expenses** | |
| ▪ The increase is attributable to inflationary adjustments associated with essential day-to-day operations (+$894,000), adequate funding for employee training and development (+$382,000), and information technology investments and architecture (+$1,100,000). | +2,376 |
| Total Funding Change, Field Operations | +4,559 |

## Support Services

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Technical Support Services | | | | | |
| Feasibility of Design Consideration | 0 | 0 | 0 | 0 | 0.0% |
| Test and Evaluation Studies | 0 | 0 | 0 | 0 | 0.0% |
| Economic and Environmental Analysis | 0 | 396 | 396 | 0 | 0.0% |
| Total, Technical Support Services | 0 | 396 | 396 | 0 | 0.0% |
| Management Support Services | | | | | |
| Administrative | 0 | 1,682 | 2,100 | +418 | +24.9% |
| ADP Support | 0 | 4,540 | 4,909 | +369 | +8.1% |
| Total Management Support Services | 0 | 6,222 | 7,009 | +787 | +12.6% |
| Total, Support Services | 0 | 6,618 | 7,405 | +787 | +11.9% |

## Other Related Expenses

| | (dollars in thousands) | | | | |
|---|---|---|---|---|---|
| | FY 1999 | FY 2000 | FY 2001 | $ Change | % Change |
| Training | 0 | 382 | 764 | +382 | +100.0% |
| Printing and Reproduction | 0 | 398 | 550 | +152 | +38.2% |
| Rent & Utilities & Telecommunication | 0 | 7,600 | 8,000 | +400 | +5.3% |
| Information Technology | 0 | 300 | 1,400 | +1,100 | +366.7% |
| Other | 0 | 1,000 | 1,342 | +342 | +34.2% |
| Total, Other Related Expenses | 0 | 9,680 | 12,056 | +2,376 | +24.5% |